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UNDERGROUND WATER.

Suggestions on How to Obtain and Care for It.

BY GEORGE BOWERS, CITY ENGINEER, LOWELL, MASS.

[*Read March 11, 1903.*]

When a city or town is obliged to obtain a new public supply of water it generally considers all the lakes, ponds, and rivers in the vicinity before investigating the underground possibilities. This is due, without doubt, to the fact that the amount of available surface water can be readily estimated, while that in the ground is liable to be considered an unknown quantity.

On account of the pollution of the Merrimac River water by sewage from towns outside our state limit, the city of Lowell was obliged in 1891 to obtain a new water supply of ten million gallons per day. In our search for this water we were advised to consider ground water as a last resource only. This at that day was considered good advice, but in the last few years there has been a great change in public opinion. Where, formerly, anything that would run through a pipe was accepted, now the people demand a good, clean, wholesome water, free from objectionable bacteria and practically colorless, a tinge of iron rust from the pipes being considered sufficient ground for complaint. This desire for better water has been recognized in a number of cases by water-works officials, and before long others will be obliged to follow their example.

The conditions necessary to meet this growing demand for purer water may often be met with in ground water, while it is exceedingly difficult to find them in surface water. When a good ground water has been obtained it is much safer water than a sur-

face supply over which a constant guard must be maintained in order to prevent pollution. Ground water is generally stored many feet below the surface, and often has an overlying stratum of practically impervious material. If, then, the water is pumped directly from the ground to the consumer, as is often the case, there is no possibility of any impurities being taken up by it, as it has been exposed to neither air nor light. If instead of this direct supply method the reservoir system is used, the best result is obtained if the reservoir is covered so as to exclude all light, thus preventing any growth of algæ in the water. This is not a difficult thing to do. In fact, in this cement age an old reservoir with sloping sides may be converted into a modern covered reservoir with comparatively little trouble.

One of the advantages of ground water is its uniformity of temperature; being so far below the surface, it is affected by the changing seasons in a comparatively slight degree. In summer it is, of course, much colder than the surface water which is exposed to the sun's heat, making it very desirable for drinking purposes. In winter the surface water is usually near the freezing point, while the underground water remaining at its normal temperature is much above that point, hence not so liable to freeze in the pipes. This last fact is a great consideration, as it makes the whole system much easier to care for during severe winters, an advantage appreciated by water-works superintendents and householders alike.

In searching for ground water as thorough a geological examination as is possible should be made of the territory selected. This must be done in order to determine the position and inclination of the underlying bedrock, and to locate the large deposits of sand and gravel, without which no great amount of water can be obtained.

If the location prove satisfactory to the geologist, test wells should be put down to verify his judgment. In many places where the surface indications might lead him to expect a good amount of water none can be found, as there is no water-bearing stratum below the surface. One great cause of failure to secure ground water is the locating of the wells in places where it is simply convenient, or where they will be near the place to be supplied. If engineers would be governed by the following rule,

they would be more uniformly successful: "Carry your well to the water; don't try to carry the water to your well."

Sometimes a city or town desiring a ground-water supply owns a piece of land from which some water can be obtained, and thinks that it is more economical to use this land than it is to purchase land which would, without doubt, yield them a good supply of water. This is a great mistake in the very beginning, for the price of the land is a very small item to be considered when you take into account the fact that this same land is expected to supply you with water forever. Another source of failure is in making a cheap and inefficient test to ascertain whether or not water can be obtained from the location in question. At this point experience and a thorough knowledge of the subject are greatly needed. When the test wells are driven the material which is brought up to the surface should be thoroughly examined, and by this examination the expert will decide whether or not the place will be able to produce the quantity of water required. Experts, of course, will not always agree, and a location condemned by one will be accepted by another, who will perhaps prove it to be an exceptionally good place.

This point was well illustrated at the very beginning of our work in Lowell. An expert drove a number of wells for us on the desired location, tested them, and pronounced them worthless. Another expert was shown the materials brought up from these wells, and said at once that he was positive that he could obtain a large quantity of water there. He was allowed to make a trial for himself. He drove several wells, and they all yielded an abundant supply, showing that his judgment was correct. Since then we have located a large plant at that place, and for a number of years have pumped from six to eight million gallons per day.

The theory that most engineers adopt and, the speaker believes, adhere to too strictly, is that the amount of ground water obtainable is a certain per cent. of the rain falling upon the visible watershed of such place. When the strata of gravel and sand in which the water is found agree in conformation with the visible watershed, this theory is right, but in reality they are seldom found to agree. The water-bearing material may extend far beyond this visible area, and a much greater supply of water may

be obtained than can be accounted for by their theory. On the other hand, with a less extent of the proper material, less water than was expected will be obtained. But when a place has been found which contains the desired material at the proper depth, and covering a sufficient area, it requires but a short time, in an average season, to determine if the supply will be permanent.

The question of location should be left to the geologist and the expert when possible. When this is decided the engineer's work begins. For one thing, he must see that no sewage is allowed to flow on the land used for the water supply, as any risk of contamination should be avoided. The land may be cultivated if it is thought advisable, but care must be taken in the selection of fertilizers used. After the location has been selected comes the sinking of the wells. The particular kind of well used depends upon the coarseness of the sand or gravel found; if it is fine a screen must be used which has a correspondingly fine mesh, but if the well is sunk in gravel an open end pipe may be used.

To obtain water that is entirely free from sand it is absolutely necessary that the well should be thoroughly made and all the fine sand around the screen removed; then when it is connected with a group and pumped by steam the result should be a perfectly clear water.

A system of wells requires care, as does anything that is expected to produce first-class results. Each well should be provided with a gate by which it may be shut off from the rest, and with a cap so that it may be opened, examined, and cleaned. Every well in use should be opened and thoroughly cleaned at least once a year, and the sand and gravel surrounding the openings or strainers should also be cleaned, and the very fine sand removed. When the well is first opened it should be pumped and the yield per minute recorded; it should then be cleaned, as stated, and pumped until the water is perfectly clear. It should then be tested and the yield taken for the yearly record.

After an experience of ten years the speaker believes that when a well is properly made and rightly cared for it will continue (the conditions being the same) to yield its original amount of water, if indeed it does not exceed it.

You should not place much confidence in people who tell you that they once had some very good wells, but that in a few years

after they were driven the volume of water decreased so much that they were obliged to abandon them. If this matter were looked into carefully it would be found that the wells were simply left to take care of themselves, or else were not properly pumped. As an illustration of this, a small manufacturing company had a good well; it was 2-inch pipe driven fifty feet, and had a few small holes drilled in the side near the bottom, and the bottom left open. For several years the well supplied all the water needed, but as the company prospered and enlarged its business, more water was required, and the engineer was obliged to pump so much from the well that it gradually drew sand and gravel into it, and instead of getting more water, they got less and less, until they gave the well up entirely. Upon investigation the speaker found that the well would yield fifty gallons per minute, but in forcing it beyond its natural capacity and trying to make it a seventy-five-gallon well they ruined it.

Another case has come to the notice of the speaker within a few days. A manufacturing company has a plant consisting of several wells. The company has enlarged its business and must have a greater water supply. On being consulted the speaker suggested that they open their wells and examine them to see if they did not need cleaning. They replied that that would be a very expensive thing to do, as they had built a large storehouse on the land over the wells. They also said that the wells had been giving out for the past few years, and that they did not consider them of much value now, but that they had paid for themselves many times over. This seems poor policy to any one who knows the value of good water and the difficulty of obtaining it.

When pumping, if only a small amount of water is required, the pumps may be run as is most convenient, but if a large amount of water is required, or if you wish to obtain all the water possible, it is better to pump the wells continuously and keep the water in the ground moving towards them than it is to stop pumping, and thus allow the current of water to change its direction.

This former method is the one adopted in Lowell, and we feel well satisfied with the result. The speaker read a paper before this Association five years ago which closed with the following statement: "The quality of the water has from the first been

excellent, and now that the quantity is assured I think we may be entirely satisfied with the result of tube well experiments in Lowell." This statement is as true to-day as it was the day it was made. We have an abundant supply of water, our wells yielding as much as when first driven. This latter fact is, of course, due in a large measure to the care they have received. It goes without saying that they have always been well looked after, as our superintendent, Mr. Thomas, is well known to you all as a man who allows nothing to escape his attention, and who is thoroughly interested in the driven wells, which are entirely under his supervision.

The opinion of the speaker is that if the state would employ a first-class geologist to whom its cities and towns might apply for advice when looking for ground water, it would prevent a great waste of both time and money. The need of a thorough knowledge of the geology of the state is appreciated more and more as the subject of underground water supply is given more attention.

The speaker wishes to call your attention to the fact that but one folio of the United States Geological Survey, showing the areal underground structure, etc., of Massachusetts, has ever been published, and this covers the region about Holyoke only. Another folio nearly completed is the Housatonic quadrangle, which takes in the southwestern part of Massachusetts and a little of New York and Connecticut. If the survey of New England were made and published, it would be a great benefit to us all, and if the members of this Association would interest their representatives to Congress in this matter, there is no doubt but the work in this section of the country might be hastened.

There is probably nothing new in this paper for engineers or superintendents who have had any experience with ground water, but it is written with the hope that it may attract the attention of some users of impure or unsatisfactory water, and cause them to investigate the conditions in their own neighborhood, with the result that they may be added to the ever-increasing ranks of the advocates of ground water.

DISCUSSION.

MR. EDWARD ATKINSON. Mr. President, a claim has been made here for Lowell, against which I wish to enter a caveat.

When it was first proposed in Brookline to take water from the Charles River, I, being a "duffer," made a thorough investigation of the subject and proved conclusively that the Charles River water was unfit to be introduced into Brookline. I then thought it better that we should join with the Metropolitan system and take our water with the rest of the section, and I proved, what was absolutely true, that the Charles River water was totally unfit for use. But the town did n't think I knew much about it, and so they went to work and got their act to take the Charles River water. Now we have water, not from the Charles River, but from the underlying stream which flows through our filter gallery, and we, sir, have the best water in the state. [Laughter.]

MR. A. O. DOANE.* My experience with driven wells was gained while I was in the employ of the city of Newton which, as perhaps a good many of you know, has a system of driven wells along the banks of the Charles River. The plant is not entirely a driven-well system, but it consists of a conduit or a collecting gallery which has wells connected into it. The wells are not pumped on directly, as in Lowell and in Brookline, but they flow naturally by gravity into the conduit, and from there the water goes through a cast-iron pipe under the Charles River to the pump well at the pumping station, so that the water is not taken in the way that is customary with driven wells. For this reason they do not get as much water from the wells as they might if they were pumped from directly, but it has proved very satisfactory so far as the quality of water is concerned; and I think probably there is a less proportion of river water taken in the supply on account of having the driven wells.

The wells are 2½ inches in diameter and were driven in accordance with Mr. Bowers' recommendation, that is, an outlet at the top with cap at surface of ground and a T with branch going into the conduit,— there is a gate on every well; and the system he recommends of cleaning out has been followed, though not perhaps as often as he requires. I think myself that it should be done every year, but it has been practiced nearer once in three or four years. The method of doing it is to put a pump on the end of the outlet, where it reaches the ground ; close the branch from the well into the conduit, and pump with a diaphragm pump,

* Division Engineer, Metropolitan Water Works, Boston, Mass.

which will take out all the sand and gravel that is loose. If it proves refractory a wash-boring tool is put in, that is, a drill with a current of water flowing through it, and any material in the well is thoroughly mixed and stirred up with the water from the force pump, and then it is again pumped, and in that way it is possible to bring the well back to its natural flow. There are records of what the wells gave when they were first connected, and they find on pumping them out again and cleaning the wells out that the natural flow is restored.

In connection with this work a modification of the Pitot tube was used to determine the flow of the wells into the conduit when we were not pumping on them, that is to say, the natural flow. It consisted of a Pitot tube having the legs lengthened so it would go down below the branch in the well tube; the air was then exhausted from the U of the tube up above by means of a little vacuum pump (the upper part of the tube being made of glass). This brought the water up into the U so the difference in level could be seen. In this way it is possible to measure the flow of the wells, and it is the only possible way in which it can be done, so far as I know. The tube was first calibrated by testing it on a known flow of water coming up through a tube in the same way that the well flows, the water being actually weighed.

MR. CHARLES N. TAYLOR.* I should like to inquire if it is necessary in a driven-well system to use a vacuum pump? Why I ask about this is that I know of a system of wells that was driven last year for the new Mt. Washington Hotel up at Mt. Pleasant. The engineer on the job was not a New England engineer. A large amount of money was expended in driving the wells. They were driven, I should say, as Mr. Bowers has suggested in every way, and connected up with one main suction pipe, and a large pump of proper design, I presume, attached to it, a permanent pump, and it was started up just before the new hotel opened, but instead of pumping water they pumped air. These wells had been tested with a diaphragm pump, and nearly all of them were found to be fairly good yielding wells. Some of them were not good yielding wells, and they were wells of different depths, but they were all connected on. Finally, the engineer thought that the wells which had n't proved to be very good

* Wellesley, Mass.

had better be shut off, and they had valves and they were shut off, and then they started again, but they still pumped air. The proprietor of the hotel never does things in a half-way manner, and he perhaps suspected that this system would not be satisfactory, and at the same time I had a contract to procure a gravity system for the hotel by going up Mt. Washington and tapping the brook up there and running the water down, so that the hotel was not out of water, for they could use it from the gravity system. But I watched the driven-well system at the same time with a good deal of interest. Another party had the contract for the wells, and they were experimenting with the wells while I was there; and I have since learned that they had continued to experiment with them until they got disgusted, having spent in the neighborhood of $40 000, and were still pumping nothing but air. The engineer in charge of the work is at a loss to know what to do about it. The contractor tells him he has got to put in a vacuum pump, but he does n't believe it is necessary to do that; and while I am not interested personally in the matter in any way, I have a curiosity to know what the trouble is with those wells, and if I can get any light on it I should like to.

MR. BOWERS. That was the very first thing I had to deal with at the beginning of my experience. The first wells we drove gave us a good deal of trouble on account of air, and people who don't know anything more about it than I did at that time will get into the same difficulty every time. To make a driven well a success it has got to be made perfectly air-tight. The ordinary castings, the ordinary pipe will leak air, so you have got to take each piece of iron separately and test it; everything which is connected with your well plant has got to be tested for air, and if it will stand the test it is all right, but if it will not it is not right. You can put on an air pump and pump the air out, and then you will get some water, but you will have to pump a lot of air unless you take these precautions.

MR. TAYLOR. These wells were driven in very porous soil, coarse gravel. There was an 8-inch casing driven down first and then the 6-inch well-pipe was put in, and the 8-inch one was drawn out; of course that left a little space, and the wells were at different depths. Would that make any difference?

MR. BOWERS. Not at all; that is, if they are 32 feet deep, they are

all right. If they are only 20 feet deep you might get into trouble if you pumped hard.

MR. TAYLOR. In pumping you will pump some of these shallow wells dry and still have water.

MR. BOWERS. Then you ruin your plant right off. As soon as you got one well dry you would be pumping air, and you would n't need to go any further.

MR. TAYLOR. I thought perhaps that was the trouble with this system, that the wells were of so many different depths.

MR. BOWERS. Do you know how deep the shallowest well is?

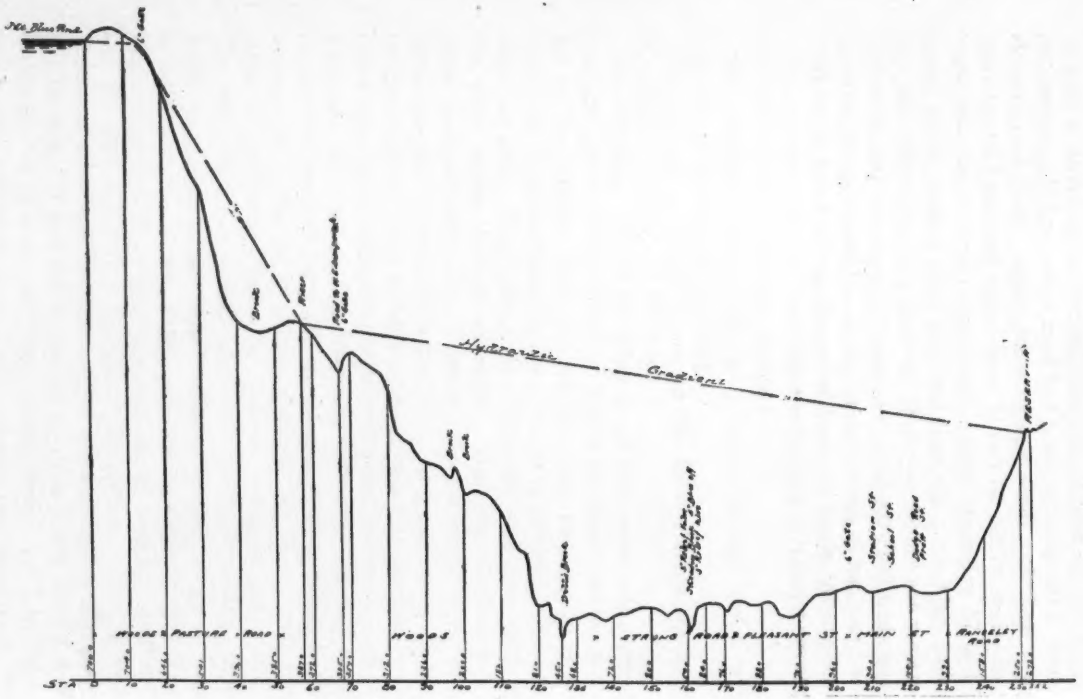
MR. TAYLOR. No; I don't have in mind just how deep, but they are none of them very deep wells.

MR. BOWERS. They ought to be below 32 feet; every well ought to be at least 32 feet deep.

MR. DOANE. I should like to ask Mr. Bowers about the form of strainer he has found the best?

MR. BOWERS. If you are going to get your water out of sand you have got to use a strainer. There is no strainer on the market in New England that you can buy; you have got to go to New York or to the West for one or make it yourself. We now make our own. They have a very fine mesh, and every drop of our water comes through a strainer. The New England well-driver does not believe in a strainer. He will put in wells with open ends and holes bored in the pipe. As I said in my paper, we have a piece of land which was tested by a New England well-driver who was considered to be as good a one as there is in New England. He went up and drove test wells over this nice piece of land, we pumped them all, and he said, "There is no water there at all." We got 20 gallons a minute out of one well, but most of them yielded but a few gallons, and some not a drop. The well which was exactly where our station is to-day, from which we can pump eight or ten millions, he could n't get a drop of water out of. It was simply because he stuck to this New England method of an open pipe, nothing to keep the sand out, and the sand would fill it right in at the bottom. Well, a New York man came into the office and he saw a sample of that sand, and he said, "If you will let me go up there I will drive a well within 20 feet of every well that he has driven, and I will give you a good well of water or I won't charge you anything." So

we let him go ahead. I did n't believe he would get a drop of water; I thought the thing had been tested and the test was all right, and that there was no water there. Well, he drove his wells there within 20 feet of these other wells, and he got from 50 to 75 gallons a minute from every one of them; the water rolled right out. He used the New York method, which has a strainer fine enough to just fit the sand, to keep the sand out and separate it from the water; and he put his strainer just where the sand was, not in the quicksand above or below: but he located it just exactly where the sand was; and all our water is got from the sand, and it is pretty fine sand, too.



SKETCH NO. 1.—PROFILE FROM SOURCE TO RESERVOIR.

HOW I REDUCE PRESSURE ON A GRAVITY SYSTEM.

BY E. H. GOWING, C.E., BOSTON, MASS.

[*Presented January 14, 1903.*]

Mr. President, — I was asked to prepare a paper for the Association, but what I have to say can hardly be called anything more than a talk about a scheme used by me at Phillips, Me., to control the pressure on a gravity system where the source of supply was about six hundred feet above the general level of the village to be supplied.

Sketch No. 1 shows the profile of the force main from the source to and through the town and to the reservoir, which is located at a sufficient elevation and on the other side of the town from the source; sketch No. 2 shows in detail the vertical riser at the reservoir; and No. 3 the vertical riser used between the source and the town at a point shown in Sketch No. 1.

The construction of the vertical riser, which I call a standpipe, is fully shown in the sketches. The Y-branch with outlet looking down is located so that the crotch of the Y is just at the proposed level of the water in the reservoir. To guard against trouble at the reservoir, I also built an overflow pipe into the embankment, the bottom of which is two or three inches above the proposed high-water level of the reservoir.

There was plenty of water and to spare in the pond from which the supply came, so it is arranged to have a little more water running than necessary to keep the reservoir full, leaving a small stream running to waste.

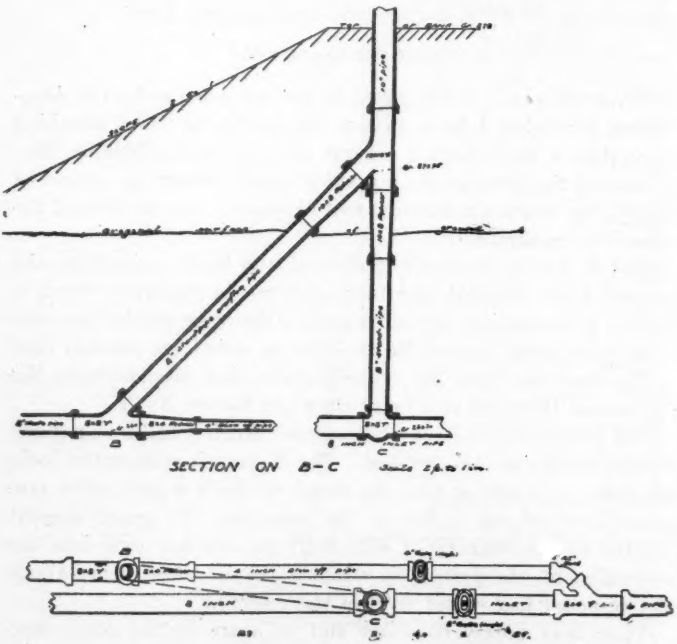
The standpipe at the reservoir was not sufficient of itself to reduce the pressure as much as was desirable, so at a point between the pond and the town, shown on the profile, another standpipe was erected. With these two standpipes the pressure was reduced so that at no point in the line was it excessive.

This arrangement is one which could only be used where there was plenty of water, but here there was an ample supply, and it

SKETCH NO. 1.—PROFILE FROM SOURCE TO RESERVOIR.

was arranged at the gate house near the source to have enough water running so that, for our domestic service, the supply was obtained directly from the source, the reservoir being kept full and, as stated, a small amount allowed to run to waste from it.

In case of fire or other exceptional demands for water, the

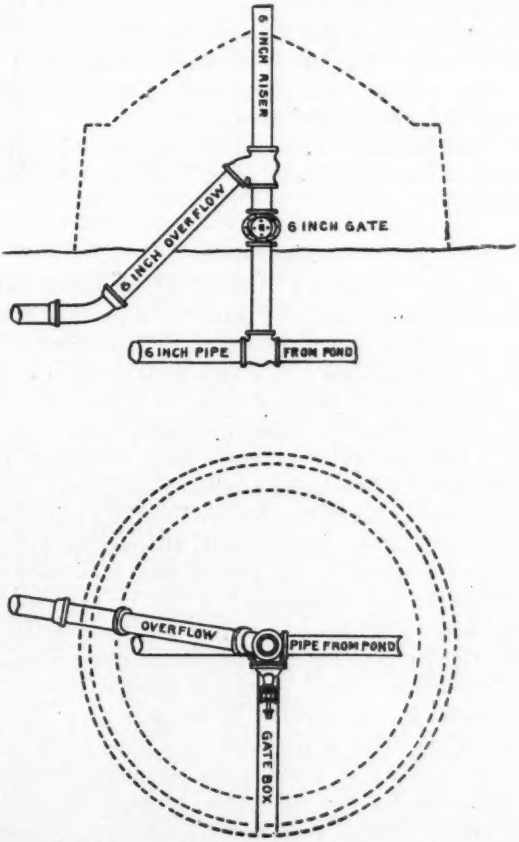


SKETCH NO. 2. — STANDPIPE AT RESERVOIR.

requirements, in excess of what is furnished from the source, are made up from water coming back from the reservoir. The pipe from the source down to the town is 6-inch, and from the reservoir to the town 8-inch; so that if the supply entered the reservoir without going through the town, there would be required at least a 10-inch pipe from the reservoir to the town to give as good service in case of fire. The system is able to throw four streams over any building in the thickly-settled part of the

town, and in some cases five, which gives all the fire protection needed in this town of about fourteen hundred inhabitants.

This arrangement of mine seems to be an automatic appli-



SKETCH NO. 3. — STANDPIPE BETWEEN SOURCE AND THE TOWN.

ance, which is absolutely reliable and needs no looking after. I have known of pressure-reducing valves being used for similar service, but I never saw an automatic machine of any kind

which I did not think needed more or less looking after, and they are apt to give out just at the time when wanted the most. These standpipes have given us no trouble, and I do not see how they can possibly do so.

This town is situated where the frost may go quite deep, and it was arranged to have the Y's buried so deeply as to be below the reach of frost. The pipe and Y's are so large that I can see no possibility of their being obstructed by anything which can go through the screens used at the source.

I have had occasion to use similar appliances in four other water-works systems, and have never heard of their giving any trouble at all.

DISCUSSION.

MR. FREEMAN C. COFFIN.* I think Mr. Gowing is to be congratulated on having plenty of water to work this device. It seems to be rather more efficient than economical of water. [Laughter.] It strikes me it is a very good thing in a place, as he says, where there is plenty of water to waste; but certainly when the draft is small the overflow or waste water must be considerable. This subject of excessive head sometimes presents quite a problem. I had similar conditions in Proctor, Vt., where there was a head of about four hundred feet, the initial head, on a gravity system. There, unfortunately, although I supposed there was no water to waste, it has proven since that there was not quite enough to use. [Laughter.] I put in a pressure-reducing valve, and I shall have to corroborate to a certain extent what Mr. Gowing says about pressure-reducing valves, judging from my experience there. There is in Proctor, however, a very efficient device in the overflow of the standpipe: the flow of water to the standpipe is regulated by a gate, which is so set that the rise and fall of water in the standpipe throughout the day compensates for the differences between the rate of flow and the rate of draft. If it does n't do that completely the standpipe overflows and water is wasted. But the experience has been that there has not been a great deal of water wasted in that way. I do not know whether there is any really reliable pressure-reducing valve or not. It is something to be de-

* Civil Engineer, Boston, Mass.

sired, and it would fill a long-felt want if there were a really good pressure-reducing valve that would n't need constant attention.

MR. FRANK L. FULLER.* I would like to ask Mr. Gowing if I understood him correctly that there was a pipe from this pond directly to the village, independent of the pipe from the pond to the reservoir?

MR. GOWING. I do not know as the sketches show that exactly, but the arrangement is that there is one pipe from the pond to and through village and to the reservoir. The first standpipe for reducing pressure is part way down, between the town and the village, and the other one is at the reservoir. There is also an overflow running through the reservoir embankment, in case the standpipe should be obstructed in any way. There is more likelihood of ice and snow in winter obstructing the overflow than of anything obstructing the standpipe.

MR. J. WALDO SMITH.† There has been a good deal said this afternoon about reducing valves which do not work. Now, I would like to give my testimony about such valves that do work. I have had occasion during the past ten years to use a great number of reducing valves of from 4 inches to 16 inches in size, about fifty in all, I think, and all of these valves have worked. Some of them have been set where the conditions were exceedingly trying. They have all been in a position where their action could be watched, and any variations shown on recording gages, and I have found in all cases that they have worked satisfactorily; like all other automatic machines, they need attention, but if they are properly taken care of I have great faith that their performance will be satisfactory.

MR. EDWIN C. BROOKS.‡ I feel that I ought to add my testimony here to the efficiency of these reducing valves. We have two, 16-inch, which have been in use about six years, and have not given one particle of trouble. We have recording gages in different parts of the city, and I think the record of those gages will show that these valves have done their work in a manner which leaves nothing to be desired. They absolutely

* Civil Engineer, Boston, Mass.
† Engineer and Superintendent, East Jersey Water Co.
‡ Superintendent, Cambridge (Mass.) Water Works.

take care of the pressure during the night within two feet static head, and all through the day the pressure on any of these gages will scarcely ever vary to exceed eight to ten feet during the periods of greatest consumption.

MR. GOWING. I do not wish to be understood as condemning all pressure-reducing valves, as doubtless there are some which will do good work. The conditions in the places where I have used this scheme are different from those usually met with, as will be understood when I say that the amount charged up last year on this particular water-works system for salary, expense, and everything concerned in the maintenance of the works was $185, $50 of which was for car-fares and traveling expenses. It will be understood that these works had to run alone, and get along without very much supervision. When there is plenty of water to waste, and it is advisable to curtail the expenses of supervision, it seems to me that something of this sort is useful.

MR. COFFIN. There are a number of pressure-reducing valves on the Metropolitan system, and perhaps Mr. Brackett can tell us something about them.

MR. DEXTER BRACKETT.* I do not know that I can say very much on this subject except to state that there are in use on the Metropolitan works five pressure-reducing valves, three of which are under our direct supervision. I think I may say that these valves are similar to other automatic machines in that they will sometimes get out of order. One of our valves has given us practically no trouble, while another of the same size, used, so far as we can judge, under exactly the same conditions, has given considerable trouble. The pressure runs up on the delivery side of the valve higher than it should at some times. Trouble is liable to occur where these valves are used for controlling the elevation of water in a standpipe if an attempt is made to control the elevation of the water within a few feet. Where the valve is used for supplying into a closed service a variation of three or four pounds makes no difference, and the valve works satisfactorily. If the pressure varies as much as eight or ten pounds it is not likely to be noticed. On the other hand, if the valve is controlling the supply into a standpipe, and it is desired to keep the water within about five feet of the top, and

* Engineer, Distribution Department, Metropolitan Water Works, Boston, Mass.

anything goes wrong with the valve, you hear from it very quickly. In cases where the pressure on the supply side of the valve varies considerably the results are not as satisfactory, as we find that under this condition the pressure on the delivery side of the valve does not remain constant. On the whole, the valves give satisfaction, and we have no desire to take them out. If you expect, however, that they will work without any attention being given to them, I should say you would be disappointed.

The thought comes to me in connection with Mr. Gowing's scheme, that a pressure-reducing valve placed on the pipe line just above the standpipe would have the effect of saving water, which might be desirable, and at the same time would prevent any undue pressure on the pipe line in case the valve failed to control the pressure.

MR. ROBERT J. THOMAS.* Before closing on this matter of pressure-reducing valves, I would simply say that any of you gentlemen who intend purchasing such valves can, by consulting the advertising pages of the JOURNAL, obtain a valve which will not give any trouble. [Laughter and applause.]

MR. FULLER. When the high service was put in at Arlington one of Mr. Ross' 5-inch valves, I think, was used. That was put in four or five years ago, and I have never heard that it has not worked satisfactorily. It was placed in the lower end of the town, where the pressure was very heavy, and so far as I know it has worked well.

* Advertising Agent, New England Water Works Association.

THE ECHO LAKE DAM, AT MILFORD, MASS.

BY LEONARD METCALF, CIVIL ENGINEER, BOSTON, MASS.

[*Read January 14, 1903.*]

About twelve miles southwest of South Framingham, Mass., lies the town of Milford, on the headwaters of the Charles River, and adjoining it the town of Hopedale. Both of these towns are supplied with water from the Charles River by the Milford Water Company, which was incorporated under Act of the Massachusetts Legislature in the year 1881. The joint population of the towns is shown by the following table:

POPULATION ACCORDING TO U. S. CENSUS.

Year.	Milford.	Hopedale.*	Total.
1880	9 310	.....	9 310
1890	8 780	1 176	9 956
1900	11 376	2 087	13 463

The water consumption has averaged during the last decade from 50 to 60 gallons per capita, as shown in greater detail by the accompanying table:

Year.	Total Annual Consumption. In U. S. Gallons.	Average Daily Consumption. Total Gallons.	Gallons per Capita.
1895	192 300 000	527 000	51
1896	234 400 000	642 000	60
1897	221 300 000	606 000	55
1898	204 200 000	559 000	48
1899	243 700 000	668 000	54
1900	310 500 000	851 000	63
1901	261 300 000	716 000	49
1902	288 800 000	791 000	51

The small per capita consumption is remarkable in view of the heavy pressure prevailing in certain parts of the town, the territory covered, and the nature of the service, — a direct pumping or so-called "Holly" system.

* The town of Hopedale was incorporated and set apart from Milford, April 7, 1886.

Analysis indicates that the present normal consumption is about 275 000 000 gallons per year, or approximately 750 000 gallons per 24 hours, and that during the summer months this amount is materially exceeded, reaching an average daily consumption of upwards of 1 000 000 gallons per 24 hours, with maximum rates of consumption of more than double this amount for short periods.

The water supply is drawn from three deep wells, the first 19 feet in internal diameter by 26 feet in depth; the second 14.5 feet in internal diameter by 25 feet in depth; the third 22 feet in internal diameter by 28 feet in depth — all yielding ground water, and from two uncovered slow sand filters, the first 0.21 acre in area, the second 0.24 of an acre in area; and from two new covered masonry slow sand filters, just completed, each of approximately one-eighth of an acre (0.130 and 0.131 acre).

The sand filters draft water from the Charles River, and discharge it after filtration into the first well, which under the recent changes has been converted into a pump well, with suitable provision for still using it when desired as a supply well. It is estimated that during the normal summer season the wells yield about 300 000 gallons per day, the rest of the water consumed being furnished by the filters.

Though not essential here, it may be of interest to state that the pumping plant (a "Holly" system) consists of three pumps — a 3 000 000-gallon "Holly" fly wheel, compound condensing pump; a 2 000 000-gallon Worthington duplex direct-acting, compound condensing pump; and a 750 000-gallon Knowles duplex direct-acting, compound condensing pump.

Analyses of the water made from time to time by the Massachusetts State Board of Health show it to be of good quality. While the number of persons per square mile of watershed is very low, the presence of certain swamp areas above the pumping station, and the possibility of contamination by the employees of the various quarries located upon the watershed near the river, made it advisable from the liberal point of view of the water company to filter the water, in order to remove all possible chance of infection and the organic matter present at certain seasons of the year, and to reduce the color of the water.

From original plans in the possession of the Massachusetts

Topographical Survey Commission,—now merged with the Harbor and Land Commission, — through the courtesy of its engineer, Mr. Henry B. Wood, a tracing was made of the vicinity of Hayden Row, Hopkinton and Milford (Mass.), from which has been determined the watershed tributary to Echo Lake above the dam, and at the pumping station of the Milford Water Company. From this plan and surveys made for the Milford Water Company, the following data were determined:

Watershed tributary to Echo Lake, including water surface, 1.53 square miles.

Watershed tributary to pumping station pond, exclusive of Echo Lake watershed, 2.10 square miles.

Total area of watershed above pumping station pond, 3.63 square miles.

Area of Echo Lake water surface to crest of old dam, 70.56 acres.

The phenomenally dry summer of 1900 threatened a shortage of water, and made it necessary for the water company to take steps toward increasing the future capacity of its water supply. The situation was therefore carefully examined, and it was determined to further develop the present sources of supply by increasing the storage capacity, and hence the yield of the tributary watershed at the pumping station. The most available means for accomplishing this proved to be by raising the Echo Lake dam, located in Hopkinton near the Milford line, on the headwaters of the Charles River ; while but 1.53 square miles of the total 3.63 square miles of watershed above the pumping station was tributary to Echo Lake, the opportunity for economically impounding the storm waters there was most unusual. The slopes of the lake shore were steep and rocky on all except the upper reaches of the pond; the amount of masonry required was comparatively small, and plenty of good granite in ledge and boulders was right at hand. Moreover, the raising of the dam resulted in increasing the mean depth of the lake without seriously increasing the area of shallow flowage; while the construction of a storage basin at any other site available would have very materially increased the area of shallow flowage. Computations based upon the Sudbury River records indicate that the mean yield of the Echo Lake watershed, over a long period of years,

would probably be about 550 000 000 gallons per annum, amounting (with a mean storage capacity of 175 000 000 gallons) to 1 500 000 gallons per 24 hours; and that in the driest year this might amount to as little as 250 000 000 gallons per annum, or 700 000 gallons per 24 hours. Investigation indicated the wisdom of raising the flow line at least 5 feet, which, bearing in mind the effect of a succession of dry years, was estimated to make possible an average daily yield, with a storage capacity of from 160 000 000 to 240 000 000 gallons, of from 900 000 to 1 000 000 gallons of water, involving a fluctuation in the lake level of from 6 to 11 feet; and in extreme cases, periods of nearly a year when the water would not fill the lake to the crest of the dam. As it was found, however, that these developments required the purchase of additional lands for flowage purposes, it was deemed expedient to increase slightly the amount of land to be bought or condemned about the lake, in order to enable the water company to control the entire watershed surrounding or contiguous to the lake. This was therefore done, and plans were drawn for raising the dam 10 feet and the flow line 9½ feet. This construction developed the following flowage areas and storage capacities:

ECHO LAKE STORAGE CAPACITY.

MILFORD WATER CO., MILFORD, MASS.

Area of tributary watershed above dam, estimated from the Massachusetts Topographical Survey Maps . . . 1 53 square miles.
Crest of wasteway of new dam . . at gr. 109 5 (assumed bench).
Crest of new dam . . . . . „ 110 00
Crest of old dam and wasteway, approximate „ 100 00

AREAS AND STORAGE CAPACITIES (AFTER SURVEYS BY L. M.)

Grades.	Areas, acres.	Capacities, gallons.
110 0	111 5	162 300 000
105 0	87 8	128 400 000
100 0	70 0	103 100 000
95 0	56 6	

The storage capacity between gr. 109.5, crest of wasteway, and gr. 110, crest of dam, is approximately 19 000 000 gallons, which is equivalent to ¾ inch rainfall over the entire watershed above the dam.

STORAGE CAPACITY IN 1-FOOT LAYERS BELOW TOP OF WASTEWAY.

Distance below Crest of Wasteway. Feet.	Volume between Crest of Wasteway and given Level below Crest. Gallons.	Volume in 1 foot of Depth above given Level. Gallons.
1	35 000 000	35 000 000
2	68 000 000	33 000 000
3	100 000 000	32 000 000
4	130 000 000	30 000 000
5	159 000 000	29 000 000
6	186 000 000	27 000 000
7	212 500 000	26 500 000
8	238 000 000	25 500 000
9	262 000 000	24 000 000
10	285 000 000	23 000 000
11	306 500 000	21 500 000
12	327 000 000	20 500 000
13	347 000 000	20 000 000
14	366 000 000	19 000 000
15	384 000 000	18 000 000

While the section of the old dam — which was of the arched form, upon a radius of about 90 feet, with a maximum height in the center of 26 feet, 19 feet base, and 5 feet horizontal crest, with vertical up-stream face, and down-stream face with a batter of 1 in $1\frac{3}{4}$ — indicated the possibility of increasing its height without further reinforcement, the uncertainty as to the character of its foundation and the very serious damage that would have resulted from a breach in the masonry, or from the undermining of its foundation, owing to the increase in the head or the the pressure of water upon it, made it necessary to determine the character of its foundation. Inquiry unfortunately developed but little definite information, and that to the effect that "the

dam was founded on rock, except for a distance of about 30 feet" (actually 48 to 60 feet) "in the center of the valley, where it was carried down into impervious hard pan for a depth of about 4 feet, the gate being but about 6 feet above the bottom of the dam, and about 2 feet above ground level; and that two thirds of the masonry was laid in Rosendale cement mortar, the remaining third in Portland cement mortar."

The work, therefore, was postponed till the latter part of the summer, when test pits were dug below the dam at the lowest points in the valley. One of these pits disclosed a footing of disintegrated granite; the second of very fine sand; the third of hard pan, underlaid with loose ledge. Plans were therefore drawn for reinforcing and partially underpinning the old dam, and the water in the lake was drawn down in September from 7 to 8 feet below the crest of the dam. This gave opportunity for the construction of a coffer dam at the narrows about 175 feet above the dam to hold back the waters of the lake during the undermining of the old structure, and thus to relieve the pressure of the water upon it. A coffer dam was built from an outcropping ledge near the center of the narrows to the easterly shore, of white pine logs, cut from the new flowage area near at hand, faced with plank and filled and reinforced with material from a borrow pit excavated in a neighboring bank. The gap on the westerly side of the ledge was stopped with sand bags. The area below this coffer dam was then drained through the 24-inch blow-off gate, discharging into a wooden flume and carrying the water clear of the excavation below the main dam.

The section first proposed for the new dam involved a maximum height of 41 feet, base 32 feet, crest 6 feet, up-stream face vertical except near the crest, where a triangle was to be cut off to reduce ice pressure, and the down-stream face with the following batters: For 12 feet down from the top, a batter of 1 in 6; then for 10 feet, 1 in 2; and below this, 1 in 1. The varying section of the old dam and the thin shell of masonry which would have resulted, at certain points, from the use of the proposed section, led to the adoption of the somewhat simplified section shown; that is, with a vertical up-stream face, 6 feet crest (with 2 feet taken out to give suitable batter to reduce ice pressure), a down-stream face with a batter of 1 in 6 for 10 feet, and 1 in $1\frac{1}{2}$

below this point, giving a maximum theoretical section of 29.4 feet (actual 32.5) on the base for the maximum height of 42.5 feet. (See Fig. 1.)

The excavation was then begun and carried down to solid granite ledge, the rotten stone being removed by picks, and blasting with ~~black~~ powder in small charges. In this way the dam was undermined about 7½ feet in depth and for a distance of about 3 feet up stream (or underneath the dam) from the downstream face of the old masonry. (See Plates I and II.)

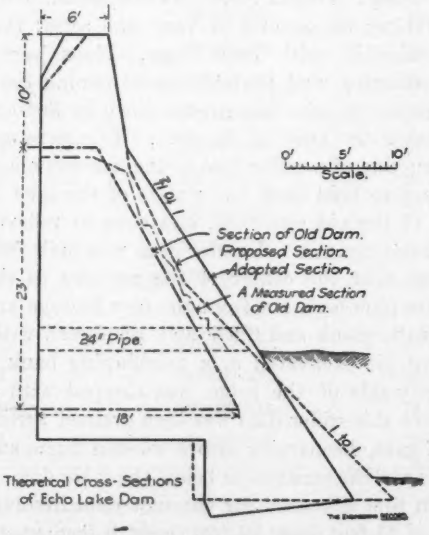


FIG. 1.

It is perhaps interesting to note that at the westerly end of the sub-foundation, lying against the nearly vertical face of the ledge or side wall of the valley, was found a vein or dike of schistose material, occurring in much the same way as the dike in the center of the valley under the new Wachusett dam of the Metropolitan Water Works. While this material did not appear to have carried any water, it could be easily excavated with a pick. The material under the main body of the old dam in the center of the valley for a distance of about 48 to 60 feet was a good, dense

PLATE I.

PLATE II.

Lake Lore from Milford Miss. Nov 3, 190
Downstream face from middle looking East
New Crest of Dam.

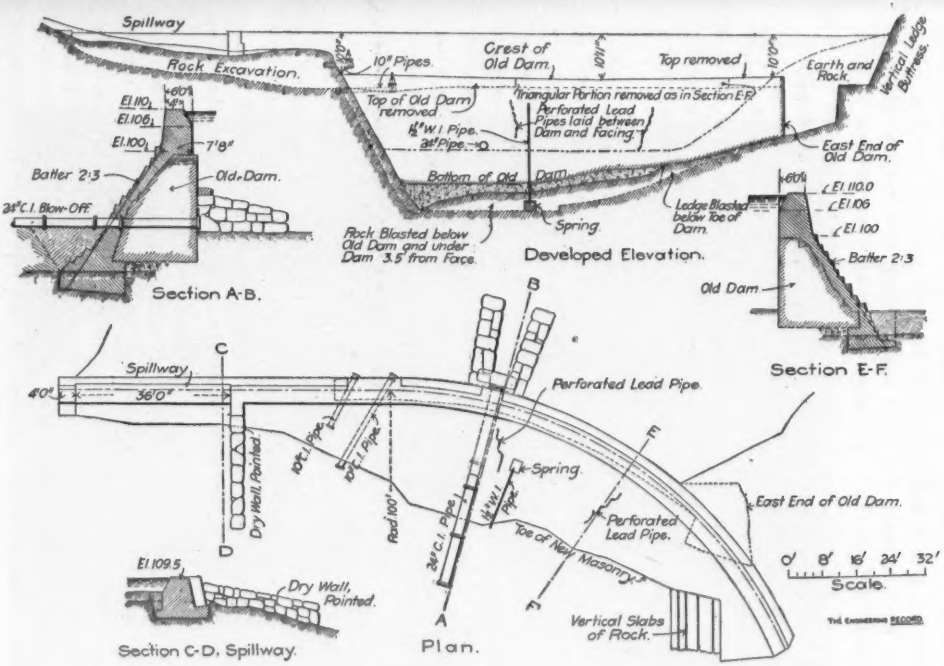

Spillway
Rock Excavation.
10" Pipes.
Crest of Old Dam.
Top removed.
Earth and Rock.
Vertical Ledge Buttress.
Top of Old Dam removed.
Triangular Portion removed as in Section E-F.
Perforated Lead Pipes laid between Dam and Facing.
East End of Old Dam.
Bottom of Old Dam.
Ledge Blasted below Toe of Dam.
Spring.
Rock Blasted below Old Dam and under Dam 3.5' from Face.
Developed Elevation.
El. 110
El. 106
El. 100
Batter 2:3
Old Dam.
24" C.I. Blow-Off.
Section A-B.
El. 110.0
El. 106
El. 100
Batter 2:3
Old Dam
Section E-F.
Spillway
Perforated Lead Pipe.
Dry Wall Pointed.
Spring.
East End of Old Dam.
Perforated Lead Pipe.
Toe of New Masonry.
Vertical Slabs of Rock.
Plan.
El. 109.5
Dry Wall, Pointed.
Section C-D, Spillway.
Scale.

FIG. 2.

hard-pan, partially underlaid with a layer of free sand and gravel. The westerly shoulder of the dam abutted upon a hard though somewhat seamy ledge; but the easterly end was found to have been built against the hard earth filling and vertical slabs of granite. (Plate III.) All loose material was removed to hard rock. A suitably rough inclined footing was blasted out of the ledge in the bottom of the valley; a trench or shoulder was cut well into the ledge on the westerly side, for a skewback for the dam arch, while the easterly end of the dam was abutted against an ideal ledge skewback or buttress of hard granite, with vertical face, normal to the thrust of the arch, which was disclosed by the excavation of the granite slabs and loose material previously referred to.

In this excavation the masonry was laid of split granite rubble, in Portland cement mortar mixed with one part of cement to two parts of sand by volume. The granite was quarried mainly on the easterly side of the valley, from outcropping ledges and large bowlders, by means of plugs and feathers and occasional charges of black powder. The rock was handled by a derrick, lifting it from the quarry to the dam, the work upon the latter being handled by two derricks located on top and at the ends of the dam, shifted in position two or three times during the progress of the work.

By a small amount of earth stripping and blasting of ledge, a spillway was built clear and free from the main portion of the dam, the water flowing over this being deflected by means of a short dry wall over the natural rock surface in a waterfall or cascade into the valley at a point about fifty feet below the main structure. Owing to the topography of this westerly hillside, it was necessary to locate this spillway on a tangent to the main portion of the dam which spans the gorge, and for this reason the latter was reinforced at its junction with the side walls of the valley, and very carefully bonded into the solid ledge. (See Fig. 2.)

While the water was drawn off below the coffer dam, the opportunity was taken for cutting out and repointing the up-stream face of the old masonry, and for carefully grouting with Portland cement mortar under a head the three or four voids or holes that were found in the masonry. All of this pointing was done with a one-to-one mixture of Atlas Portland cement.

PLATE III.

Two points in the method of construction adopted involved serious consideration: First, the possibility of an upward pressure over a considerable area of the foundation or bottom of the old dam, owing to the fact that it was not founded upon ledge; and, second, the possibility of a bursting pressure between the old and new layers of masonry, owing to leakage of the old structure and the practical impossibility of obtaining a perfect bond between the old and new walls. Both the old and the new sections of the dam were designed as gravity sections, without allowance for the additional stability afforded by the arched form, and it will be seen from the accompanying diagram that even with an upward pressure over a portion of the footing of the old dam the line of resistance would fall well within the new base. As an additional precaution, however, a small, dry well was left underneath the dam just up-stream from the new masonry, with a 1½-inch wrought-iron pipe passing through the masonry and discharging freely down stream. This well was located at a point where a spring was found coming up through a seam in the ledge, and measurements were made of the amount of water percolating through the pipe. Since the completion of the work the flow of water through this pipe has been observed from time to time, but no evidence of increased seepage or leakage has been found. Several springs of this sort were encountered in laying the footing masonry, but their origin appeared to be in the nature of ground water from the hillside above, rather than from the lake itself.

As regards the bonding of the two layers of masonry, it should be noted that the foundation was exceedingly well bonded into the footing ledge, and that it is further assisted by the thrust of the dam under pressure of the water; that both ends or sides of the dam abutting upon the slopes of the valley were reinforced and unusually well bonded into the ledge, and that a portion of the top of the old dam was removed, and the new work was bonded into and over the old masonry. Moreover, the effect of the arch is probably to bring the old and the new faces of the masonry tightly in contact. As an additional precaution, however, two perforated 1-inch lead pipes were laid against the down-stream face of the old structure, following vertically said face, and built into the new masonry, so that in case of the develop-

ment, through leakage or other cause, of a considerable area of hydraulic pressure between the two layers of masonry, this seepage or leakage water may be drained out by these pipes before it can develop large areas of such stresses. Up to this time no leakage has been apparent in these pipes, but the fact should not be overlooked that the lake has not yet had opportunity to fill to the new flow line.

As already briefly alluded to, a triangle of masonry is cut off on the up-stream face (2 feet on the crest and 4 feet vertically down), giving a batter to the face of 1 in 2, in order to reduce the danger from ice pressure; and the bottom is sloped by paving with large granite blocks at and near the spillway for the same reason.

After completion the crest of the dam was cut and dressed to line with hammer and pointed, and all joints were pointed with one to one Portland cement mortar.

Two 10-inch blow-off gates are provided, located at 8 and 14 feet respectively below the flow line.

It was thought inexpedient to strip the new flowage area, owing to the expense involved and the character of the stream between the dam and the pumping station, particularly in view of the fact that the water is all filtered through slow sand filters before use. The area was therefore merely cleared with ax and brush hook.

The quantities of masonry involved and the items of cost are not here given, for the reason that the work was of such special nature as to make such figures of little value for purpose of estimating elsewhere, without a very intimate knowledge of all the local conditions, some of which were quite unusual. It may be of interest to note, however, that the cement used amounted to 0.83 of a barrel per cubic yard of masonry (which is equivalent to 1.2 cubic yards of masonry per barrel of cement), based upon the entire work, including all foundation work, pointing, grouting, etc.; while the rubble masonry itself required in the mass work about 0.7 barrels of cement per cubic yard of masonry.

The speaker takes pleasure in acknowledging his indebtedness for hearty coöperation and assistance to Mr. J. William Kay, Superintendent of the Milford Water Company; to Mr. A. T. Safford, Consulting Engineer, of Lowell; and to Mr. William T. Barnes, Resident Engineer on the work.

PLATE IV.

FIG. 1. — REËNFORCING OLD DAM.

FIG. 2. — COMPLETED DAM — SOUTH SIDE.

FIG. 3. — COMPLETED DAM — LOOKING EAST.

PLATE V.

THE WATER SUPPLY OF NEW ORLEANS AND ITS IMPROVEMENT.

BY ROBERT SPURR WESTON, SANITARY EXPERT, BOSTON, MASS.

[*Read February 11, 1903.*]

When one visits Louisiana, particularly New Orleans, for the first time, his attention is forcibly turned toward the rain water cisterns which are attached to nearly every building. Many of these cisterns are two-storied. This construction permits the supplying of the upper floor during times of drought, as the rain water usually runs first into the upper cistern and then overflows into the lower. The large rainfall is utilized for the domestic supply, because of the poor quality of the ground water and the hardness and muddiness of the river water, the two other available sources. Nine tenths of the city's domestic supply is from the cisterns and the remainder from the Mississippi River, the water of the latter also being used for protection against fires and for flushing gutters. The quality of the rain water varies from very good to very bad, depending upon the location and nature of the collecting surface, the construction of the cistern, the character of the surrounding atmosphere, the season of the year, etc.

Naturally the well-constructed and well-cared for cisterns collecting water from clean roofs in the more open parts of the city, and automatically wasting the first portions of each shower before turning the rain water into the cisterns, may be expected to furnish satisfactory water. On the other hand, the seldom-cleaned, open cisterns, receiving the washings of befouled, dusty, and decaying shingle roofs in the thickly-settled districts, are undoubtedly frequent sources of infection.

Two conditions, however, militate against the use of even the most excellent cistern, namely, the long dry season and the increased use of water due to the increasing amount of sanitary plumbing. Again, the construction of the proposed sewerage

system will invite the construction of more house plumbing, and will consequently demand more water than the sixty inches of rainfall can supply. Already many of the better class of houses use the rain water for cooking, drinking, and laundry purposes only, while the river water is used at the sinks, lavatories, baths, and water-closets. Still other houses are provided with small filters, some of which filter river water to supply the whole house, thereby doing away with the questionable cistern water and its unsightly container.

The necessity for soon obtaining a more abundant and satisfactory water supply for New Orleans has been realized for some time, and a Sewerage and Water Board was constituted by a legislative act of 1899 to build new water supply and sewerage systems. To defray the cost of these works a two-mill tax was levied, which permits a bond issue of about $12 500 000.

There exists here the unusual example of an American city without sanitary sewers and with only about one tenth of the houses connected with the existing mains of the local water company.

Three sources of water supply were proposed; namely, the rivers to the north of Lake Pontchartrain, the ground water from local deep wells, and the Mississippi River.

The water of the rivers north of the lake is generally uncontaminated by sewage, but would certainly require storage or filtration before use, to perfect its appearance and protect it against chance contamination. This purification and more especially the cost of a long conduit, pumping machinery, etc., exceeding the available fund, prohibited the adoption of this source of supply.

The water of the deep wells, while excellent for use in steam boilers, is alkaline, and has such a high color that purification would be necessary were it used for domestic purposes. This purification would be expensive. Furthermore, the possibility of assuring a supply from this source is doubtful, and was enough in itself to prevent the serious consideration of this source of supply.

There remained only the Mississippi River, abundant, near at hand, and contaminated only at remote points, but, on the other hand, moderately hard, and laden with suspended silt and clay.

Previous attempts to purify the river water made by the New

Orleans Water Works Company in 1892, using mechanical filters with coagulant, but without preliminary subsidence of the raw water, had resulted in a costly failure, and therefore grave doubts were expressed regarding the practicability of any system of water purification, especially upon a municipal scale. However, the Sewerage and Water Board was advised by its experts that if the river water were subjected to proper preliminary treatment it could be filtered afterward without serious difficulty.

Upon the advice of Mr. George G. Earl, M. Am. Soc. C. E., its chief engineer, the board decided to conduct an investigation as to the feasibility of purifying the Mississippi River water, under the general supervision of Mr. George W. Fuller, Assoc. M. Am. Soc. C. E., the consulting sanitary expert of the Board, and Mr. Earl, and under the immediate charge of the speaker.

WATER PURIFICATION INVESTIGATION.

A water purification station was established at Audubon Park, and during the flood season of 1900–01 the behavior of the Mississippi River water was observed under various systems of treatment, and after various periods of subsidence, with and without the aid of a coagulant. A plan and section of this station, reduced from an illustration in the *Engineering Record*, is shown in Fig. 1.

This station contained four complete and adjustable systems of water purification, having a total daily capacity of 93 000 gallons per diem, or enough for 1 500 people. Each system consisted of subsiding basins and filter. The basins could be operated either with or without the aid of a coagulant, and the four filters, two slow and two rapid, were supplied with the effluents from one or another of the basins. Thus was it possible to study, among other things, the effect of plain subsidence for various periods, the effect of supplementary subsidence with a coagulant, the efficiency of the various methods of filtration, the effect of various-sized sands, the effect of various rates of filtration, etc., and to compare the data one with another. The station was equipped with an adequate laboratory, and the work of the station was performed by a staff of four trained and four untrained assistants, besides the speaker. The cost of the investigation was something over $24 000, an expense which will undoubtedly

effect a saving of several times that amount, besides furnishing valuable initial data for the operation of the plant in practice.

The details of the investigation, including the results of several thousand analyses, are given in a recent report to the chief engineer of the Sewerage and Water Board.

Among other things, the investigation determined the character of the Mississippi River water, the most efficient and economical method of treatment of the water before filtration, and the most efficient and economical method of filtration, and besides, furnished important data for estimating the cost of the proposed systems of purification.

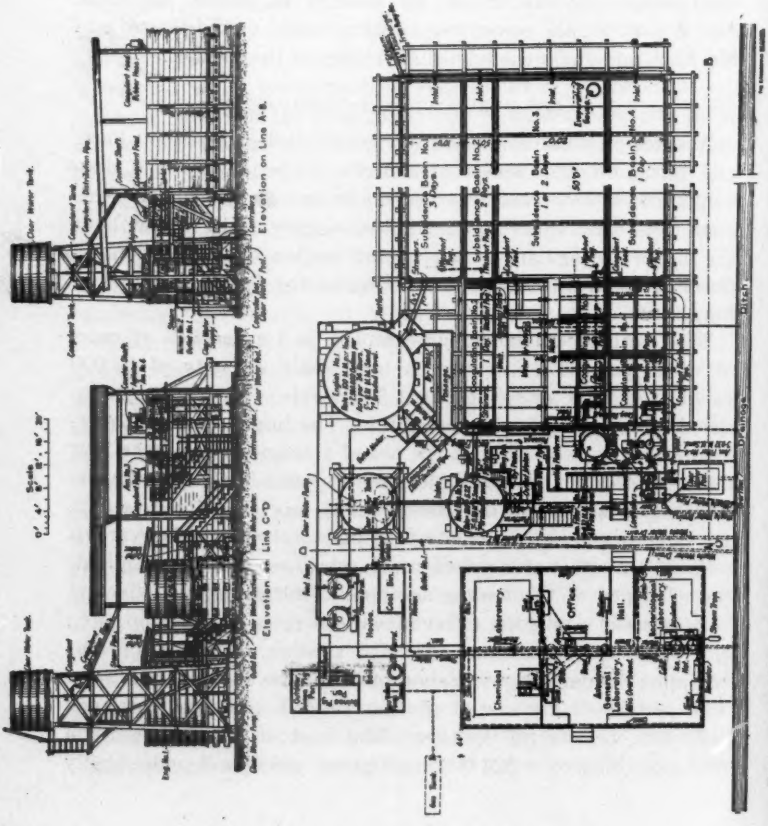


FIG. 1.—PLAN AND SECTION OF EXPERIMENTAL WATER PURIFICATION STATION.

COMPOSITION AND CHARACTER OF THE MISSISSIPPI RIVER WATER.

The Mississippi River is a clay-bearing stream, whose water at New Orleans possesses the following characteristic features: —

1. Wide variation in the amount of suspended matter. This variation is not so marked, however, as in many of its tributaries.

2. The comparatively large proportion of the suspended matter made up of fine clay particles.

3. The absence of sudden changes in the amounts of suspended matter in the water.

4. The frequent but not sudden changes in the character of the water, due to the predominance of one or another of the tributaries.

5. The absence of appreciable evidences of sewage contamination. This is because of the great dilution of the sewage entering the stream, the remoteness of the sources of pollution, and the almost complete purification effected in the river itself by natural agencies during the stream's passage through the delta, the surface of which drains away from, instead of into, the river.

It may be well at this point to give a brief description of the watershed, which, of course, determines the character of the river water at New Orleans.

You will recall that the watershed of the Mississippi has an area of 1 240 000 square miles, distributed among thirty-one states and territories, and its diversity of character may be readily comprehended when one considers that within the Mississippi River basin are the slopes of the Alleghanies and the Rockies; the lakes of Minnesota and the West; the limestone farming country of Kentucky and Tennessee, and the black bottoms of the Dakotas; the arid plains of the Central West and Colorado, and the swamps of the Central Valley.

The Mississippi basin is made up of six tributary basins; namely, the Ohio, upper Mississippi, Missouri, Arkansas, Red and Central Valley.

You are aware of the fact that because of the wide variations in amount of rainfall in different parts of the basin, and because of the varying character of the soil and climate, the discharge of the several tributaries is not uniformly proportional to the area of their several basins. The following table shows the rank of

FIG. 1.—PLAN AND SECTION OF EXPERIMENTAL WATER PURIFICATION STATION.

each basin as regards stream discharges, areas, and rainfalls, as compared with one another:

Basin.	Rank, Based Upon		
	Stream discharge.	Area.	Rainfall.
Ohio	1	2	2
Upper Mississippi	4	4	4
Missouri	3	1	6
Arkansas	5	3	5
Red	6	5	3
Central valley	2	6	1

This table illustrates, among other things, the well-known fact that the discharge of the Missouri River is much less than the discharge of the Ohio, although its area is much greater.

The amount of rainfall varies from 0 to over 60 inches, and averages 29.8 inches per annum, according to the best authorities. This rainfall results in a stream discharge of from 200 000 to 2 000 000 cubic feet per second, or, in other words, from .12 to 1.2 cubic miles volume of water per day.

As has been stated previously, the contamination of the river by sewage is not at all serious in comparison with that of most other American streams. One is so accustomed to hear the Mississippi River called the "main sewer of the continent," "natural carrier of the waste of a teeming civilization," etc., that he is surprised to find that it is a difficult matter to demonstrate by the most delicate tests that the local river has been contaminated. This is evidenced by the fact that Bacillus coli communis was discovered only once or twice in five months, although 300 cc. portions of the water were taken for each determination, and that Bacillus enteriditis sporogenes (Klein), which is readily isolated from the Red River water at Shreveport, was found at New Orleans on but one occasion.

The urban population of the valley is estimated at 9 000 000 people, including all towns which have a population of 4 000 or more, as determined by the United States census of 1900.

Only four cities, with a combined population of 43 961, discharge their sewage into the river within 600 miles of New Orleans, while the leveed banks prevent the accession of surface drainage.

As you well know, the land of the delta is necessarily highest at the banks of the stream, thus preventing surface drainage into the river. It is evident that the dilution of the contamination is enormous, and that much opportunity is given for the self-purification of the stream by natural agencies while it flows on its way to the Gulf.

The Mississippi River is a very muddy stream, containing on an average about 2.7 tons of suspended matter per 1 000 000 gallons of water. This means that any system of purification must remove enough silt and clay from the future water supply of New Orleans to cover four city squares three feet in depth per annum.

The economical clarification of the water by the removal of the clay and other suspended matter is, therefore, indirectly the chief end of any system of water purification at Orleans, and experience during the investigation confirms the opinion that this removal of clay is accompanied by an adequate removal of bacteria and color, thereby guaranteeing protection against disease bacteria, which might perhaps at some time be present in the unfiltered water.

Many thousand analyses have been made to determine the composition of the river water, with the result shown in the following summary:

SUMMARY OF AMOUNT OF CONSTITUENTS FOUND IN THE RIVER WATER FOR THE PERIOD BETWEEN DECEMBER 10, 1900, AND AUGUST 17, 1901.

	Parts per million.		
	Maximum.	Minimum.	Average.
Silica turbidity	1 460	90	405
Total suspended matter	1 040	75	440
Total dissolved residue	250	80	145
Suspended albuminoid ammonia	0.598	0.015	0.188
Nitrogen as total albuminoid ammonia	0.677	0.054	0.251
Nitrogen as free ammonia	0.036	0.000	0.012
Nitrogen as nitrites	0.023	0.000	0.008
Nitrogen as nitrates	0.56	0.02	0.14
Chlorine	20.9	6.0	9.2
Incrusting constituents	24	5	14
Dissolved oxygen	11.5	5.3	9.0
Alkalinity	115	57	79
Free carbon dioxide	75	0	34
Bacteria per cu. centimeter	6 500	60	2 065
Temperature, degrees C. (F.)	31.1(88)	7.0(44.6)	17.6(63.8)

From data collected during the investigation and obtained from the Mississippi River Commission, it was possible to determine closely the physical character of the river water, as is shown in the following summary:

SUMMARY OF THE PHYSICAL DATA.

Average suspended matter, 1900–01, 441 parts per million.
Average silica turbidity, 1900–01, 406 parts per million.
Average turbidity coefficient, 1900–01, 1.08.
Average recorded suspended matter, fifteen years, *688 parts per million.
Average suspended matter, corrected for analytical errors, 650 parts.
Average turbidity coefficient for 22 samples of water having between 600 and 700, and averaging 648 parts of suspended matter per million, 1.07.
Estimated mean silica turbidity, 600 parts.
Maximum suspended matter, 1900–01, 1 040 parts.
Mean maximum suspended matter, 15 years, * 2500 parts.
Estimated mean annual maximum silica turbidity, 1 500 parts.
Estimated mean annual minimum silica turbidity, 125 parts.

Methods of Purification.— Three general steps in the systems for complete clarification and purification have been considered in various combinations, as follows: —

1. Plain subsidence in basins for several days.
2. Supplementary subsidence in basins with the aid of a coagulant.
3. Filtration, either at a slow rate through sand beds — English filters — or at a rapid rate through filters provided with mechanical devices for cleaning the sand — American system.

1. PLAIN SUBSIDENCE — RELATIVE FINENESS OF THE SUSPENDED MATTER.

The suspended silt and clay in the Mississippi River water at New Orleans contains much very fine material, immeasurably finer than the smallest bacteria. This is probably because of the opportunity afforded for sedimentation of the larger particles during ordinary stages of the river, on the bed of the river itself. These larger particles then become broken into or worn to sizes which can be carried down stream by the lower velocities which obtain in the last few hundred miles of the river.

An idea of how fine these particles are may be obtained by comparing the approximate percentage of suspended matter

* Report of Mississippi River Commission.

removed from the local water for twenty-four hours of plain subsidence with that removed from the muddy waters of other localities for the same period of subsidence, as follows:

Kansas City. Missouri River, estimated percentage removal of suspended matter in twenty-four hours, 82.

Cincinnati. Ohio River, estimated percentage removal of suspended matter in twenty-four hours, 62.

New Orleans. Mississippi River, estimated percentage removal of suspended matter in twenty-four hours, 45.

Plain Subsidence Inadequate to Prepare Water for Filtration at all Times. — On account of the large amount of fine clay particles, the suspended matter as a rule is held in suspension indefinitely, and cannot be removed after any practical periods of plain subsidence, even periods of a week or more.

English Filters and Plain Subsidence. — When this subsided water is filtered at slow rates through thick layers of fine sand a satisfactory clarification and purification results for but a portion of the time. This system would produce muddy effluents for months at a time, and, what is more serious, the cost of cleaning and renewing the clogged sand layer would be prohibitive.

2. SUPPLEMENTARY SUBSIDENCE WITH THE AID OF A COAGULANT.

Necessity of Coagulant. — Since the fine particles of suspended matter cannot be removed by plain subsidence, it is necessary to add something to the water to bring them together in aggregates or groups, which of themselves would have a subsiding value great enough to cause them to settle within a reasonable period. Sulphate of alumina can be used for this purpose, and when added to the water forms an insoluble gelatinous precipitate which, uniting with the clay, causes it to gather into flocks or aggregates, which settle much more rapidly than the diffused clay particles themselves. This precipitate also has the power of attracting, enveloping, or absorbing stray particles of suspended matter, including bacteria, so that the water by this method of coagulation and supplementary subsidence can be made fairly clear.

Difficulty of Removing Last Traces of Turbidity by Coagulant. — In practice, water which has been purified by plain subsidence

followed by supplementary subsidence with a coagulant is, strictly speaking, never perfectly clear. This is because it is difficult to remove the last traces of turbidity by this process alone. Indeed, it is much more satisfactory to make the final step in the clarification and purification process by the use of a suitable filter.

3. METHOD OF FILTRATION.

Two kinds of filters can be used for this final clarification and purification of the effluent of the coagulating basins, namely, the English and American filters. These filters are well known to you all. The English system, you will recall, consists of a bed of sand through which the water, without coagulation, but after being subjected to plain subsidence, filters at a slow rate, while the American system treats the water after both plain subsidence and also supplementary subsidence with the aid of a coagulant, and filters it at a rapid rate through a bed of sand, which is intermittently freed from matter which obstructs the passage of water by reversed currents of water and by agitation. In the English filter the accumulated matter which clogs the filter is removed by draining and scraping.

The main features of the two filters, however, are compared as follows, the English filters being covered and the American filters partially covered:

Area of units: about 1 acre English, 15 x 24 feet American.

Area of 40 000 000-gallon plant: ten acres English, 0.32 acre American.

Net yield or rate of filtration, million gallons per acre per twenty-four hours: 4 English, 125 American.

Depth of sand (inches): 36 English, 30 American.

Depth of gravel (inches): 12 English, 4 American.

Underdrain system: drain tiles and conduits English, pipe system of double bottom and metal strainers American.

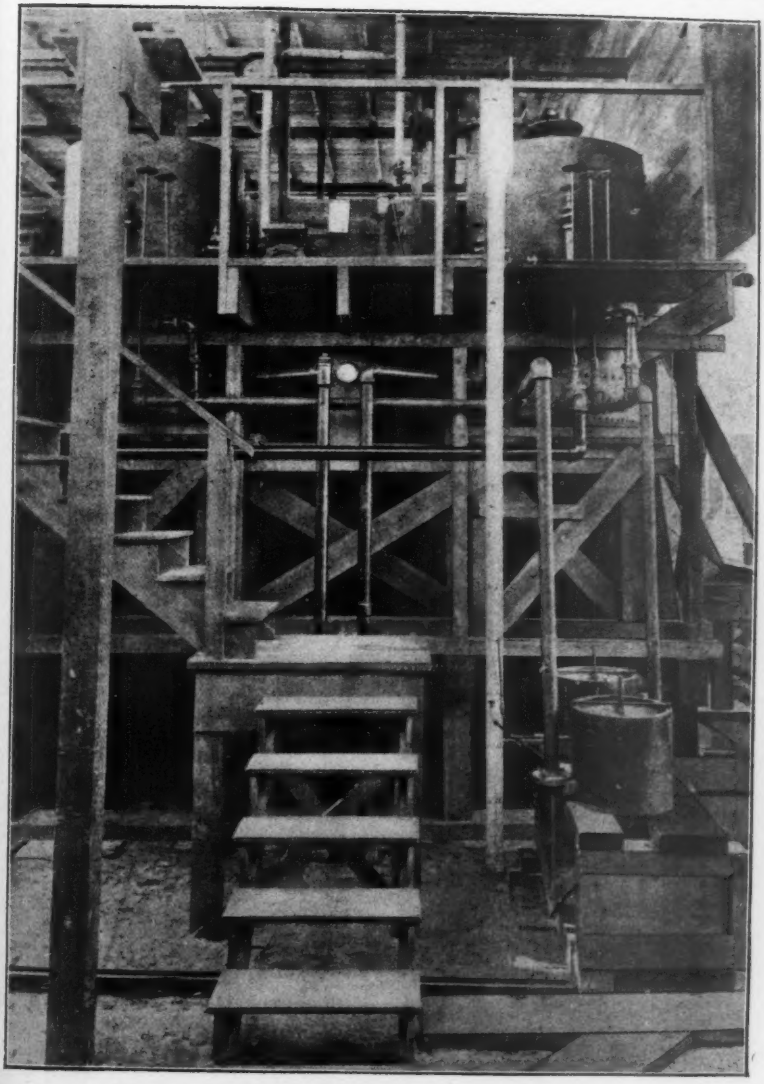
Clogged sand layer cleaned by: draining and scraping English, washing with filtered water until cleaned American.

Vertical height of structure: 14 feet English, 15 feet American.

Relative efficiency for clay removal and relative bacterial efficiency: satisfactory in both.

Both Filters Applicable. — Both filters would be applicable to the purification of the Mississippi River water, provided suitable arrangements for plain subsidence and supplementary subsidence with the aid of a coagulant were provided.

PLATE I.



General View of American Filters and Controllers.

The sizes and arrangements of the two systems of purification may be compared as follows: —

	Modified English System.	American System.
Total daily capacity of plant, gallons	40 000 000	40 000 000
Capacity of plain subsidence basin in hours flow	12	12
Capacity of coagulating basin in hours flow	24	12
Average amount of coagulant, grains per gallon	3.7	4.5
Coagulant used	Practically continually.	Continually.
Approximate first cost of plant	$1 260 000	$700 000
Total estimated cost of purification per million gallons, including interest, depreciation and operating expenses, as well as pumping water from river to suction of high lift pumps	$16.46	$15.00

It is seen that the American system is less expensive to construct for use in New Orleans than the modified English system by more than $500 000.

Selection of System Best Adapted to Local Conditions. — Either filter would be adapted to the purification of the Mississippi River water, and the decision as to which would best suit local conditions should be dependent upon the cost per million gallons of filtered water, taking into consideration the difference in first cost.

In total first cost the American system is fully 25 per cent. cheaper than the modified English system, when estimates are made up on the same basis.

Careful Supervision Necessary with Both Systems. — Both systems require careful supervision and attention, as is obvious.

FINAL CONCLUSIONS.

In conclusion, it may be said that the present water supply of New Orleans is neither satisfactory nor abundant, and that sufficient data has been collected during the investigation to allow a system of water purification to be designed which will efficiently and economically purify the Mississippi River at New Orleans.

Furthermore, the available evidence shows that the American system is best adapted to local conditions on account of its low first cost, coupled with adequate efficiency.

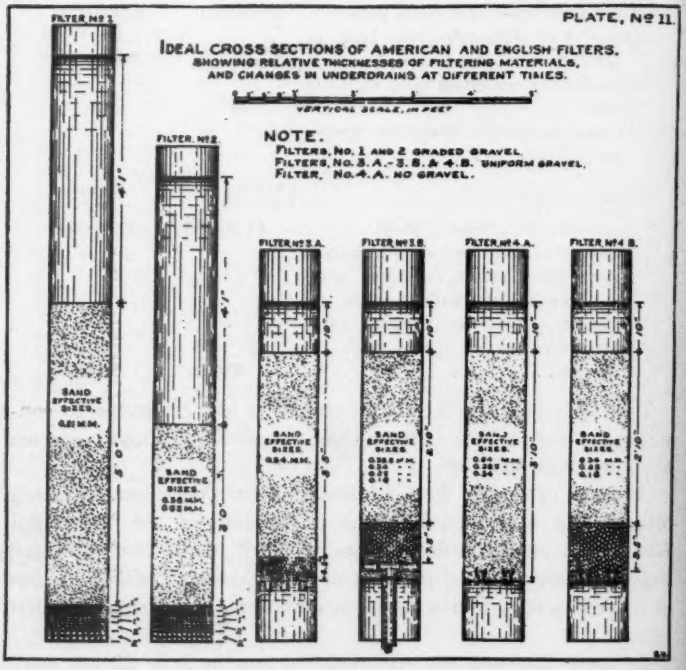

PLATE, Nº 11.
IDEAL CROSS SECTIONS OF AMERICAN AND ENGLISH FILTERS.
SHOWING RELATIVE THICKNESSES OF FILTERING MATERIALS,
AND CHANGES IN UNDERDRAINS AT DIFFERENT TIMES.
VERTICAL SCALE, IN FEET
NOTE.
FILTERS, No. 1 AND 2 GRADED GRAVEL.
FILTERS, No. 3. A.-3. B. & 4. B. UNIFORM GRAVEL.
FILTER, No. 4. A. NO GRAVEL.
FILTER, Nº 1.
FILTER, Nº 2.
FILTER, Nº 3 A.
FILTER, Nº 3 B.
FILTER, Nº 4 A.
FILTER, Nº 4 B.
SAND EFFECTIVE SIZES.

FIG. 2.

During the investigation frequent changes were made in the sand used in the rapid filters, and the bacterial efficiency suffered accordingly. Since the investigation, however, one of the units has been operated for the purpose of supplying water to the wading pool in Audubon Park. Although this plant has been operated during part of each day only, it has shown a bacterial efficiency of 98.2 per cent. This is certainly in excess of the requirements. Furthermore, the appearance and taste of the purified water leave little to be desired.

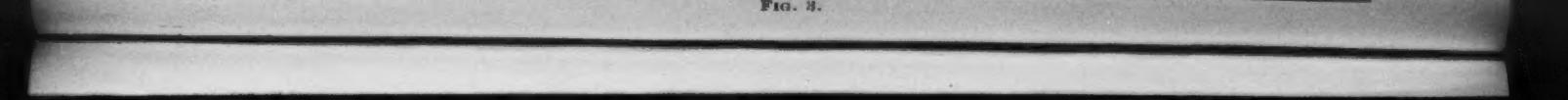


FIG. 3.

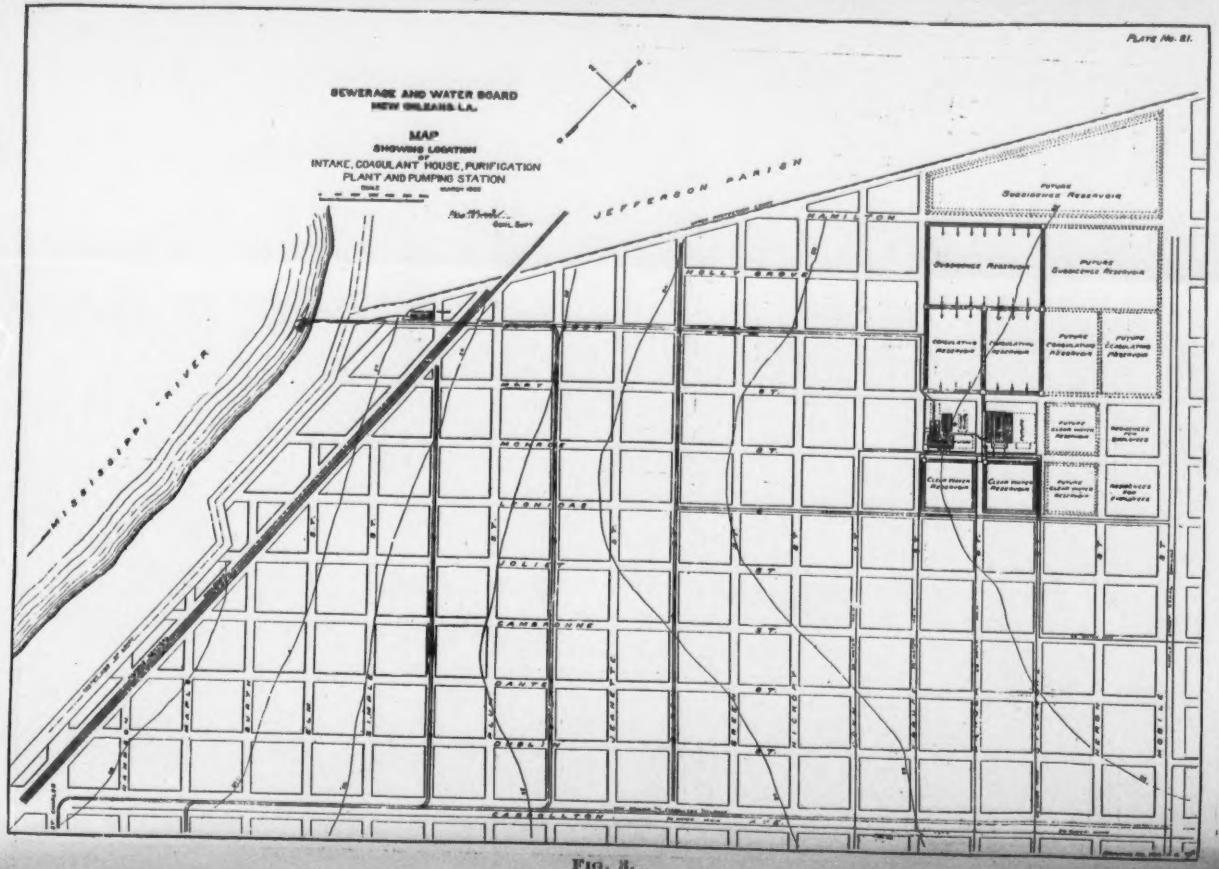


PLATE No. 81.
SEWERAGE AND WATER BOARD
NEW ORLEANS LA.
MAP
SHOWING LOCATION
OF
INTAKE, COAGULANT HOUSE, PURIFICATION
PLANT AND PUMPING STATION
JEFFERSON PARISH
MISSISSIPPI RIVER
HAMILTON
HULL
BROOME
MARY
MONROE
LEONIDAS
JOLIET
CAMBRONNE
DANTE
DUBLIN
CARROLLTON
FUTURE SUBSIDENCE RESERVOIR
SUBSIDENCE RESERVOIR
FUTURE SUBSIDENCE RESERVOIR
COAGULATING RESERVOIR
COAGULATING RESERVOIR
FUTURE COAGULATING RESERVOIR
FUTURE COAGULATING RESERVOIR
FUTURE CLEAR WATER RESERVOIR
RESERVOIRS FOR EMERGENCIES
CLEAR WATER RESERVOIR
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FUTURE CLEAR WATER RESERVOIR
RESERVOIRS FOR EMERGENCIES

FIG. 3.

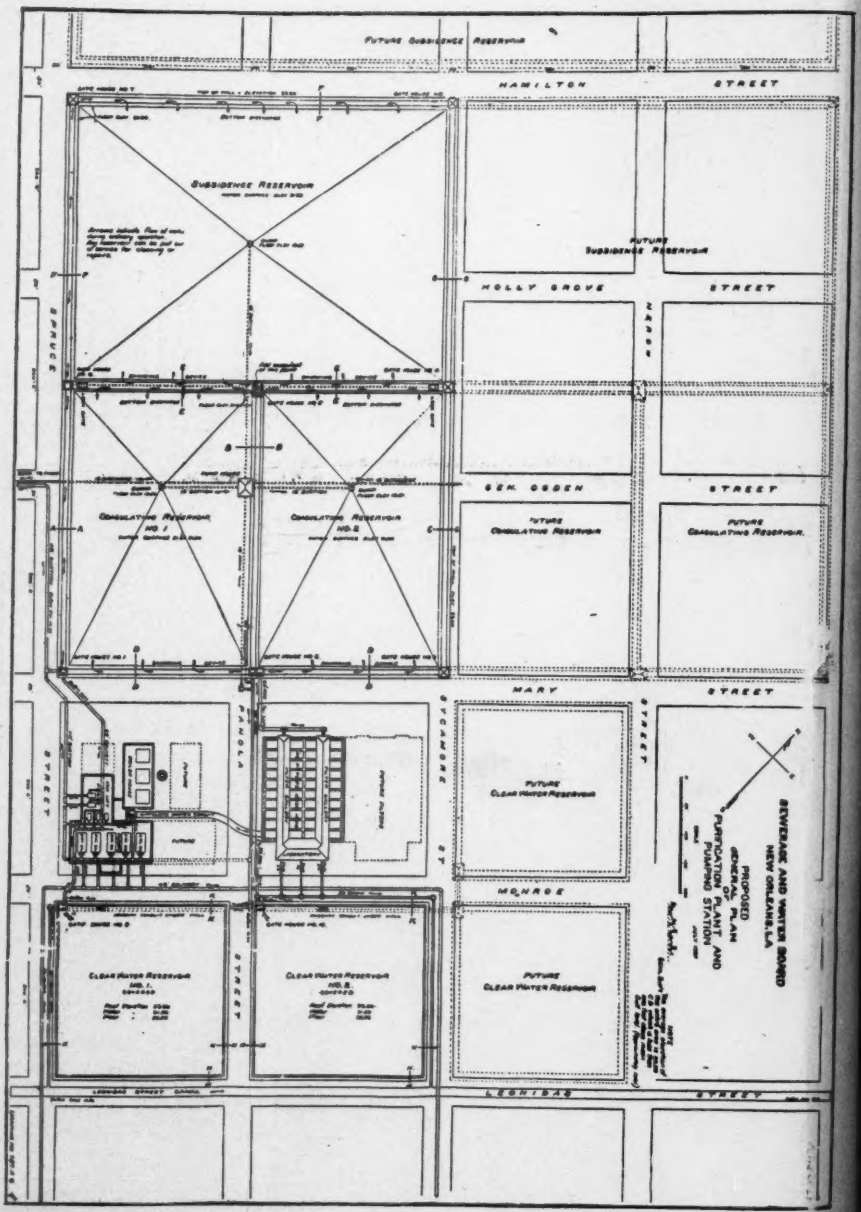
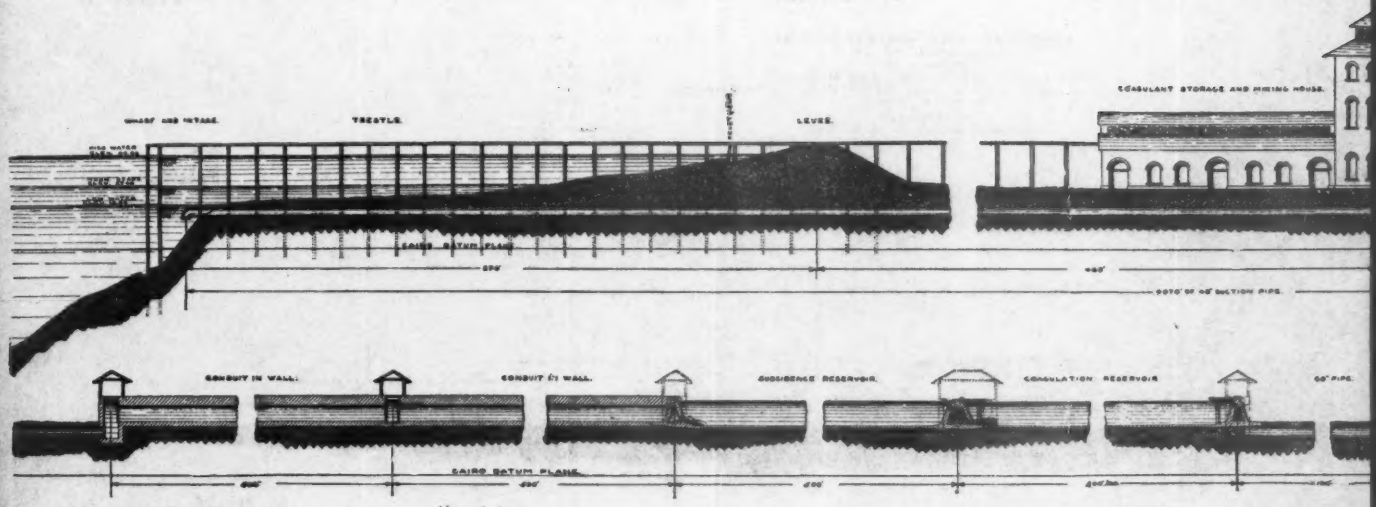

FUTURE SUBSIDENCE RESERVOIR
HAMILTON STREET
SUBSIDENCE RESERVOIR
FUTURE SUBSIDENCE RESERVOIR
HOLLY GROVE STREET
SPRUCE
MAPLE
GEN. OGDEN STREET
CIRCULATING RESERVOIR NO. 1
CIRCULATING RESERVOIR NO. 2
FUTURE CIRCULATING RESERVOIR
FUTURE CIRCULATING RESERVOIR
MARY STREET
PANOLA STREET
SYCAMORE ST
STREET
FUTURE CLEAR WATER RESERVOIR
MONROE
SEWERAGE AND WATER BOARD NEW ORLEANS, LA.
PROPOSED GENERAL PLAN OF PURIFICATION PLANT AND PUMPING STATION
CLEAR WATER RESERVOIR NO. 1
CLEAR WATER RESERVOIR NO. 2
FUTURE CLEAR WATER RESERVOIR
LEONIDAS STREET

FIG. 4.


WHARF AND INTAKE
TRESTLE
LEVEE
COAGULANT STORAGE AND MIXING HOUSE
CAIRO DATUM PLANE
CONDUIT IN WALL
CONDUIT IN WALL
SUBSIDENCE RESERVOIR
COAGULATION RESERVOIR
CAIRO DATUM PLANE

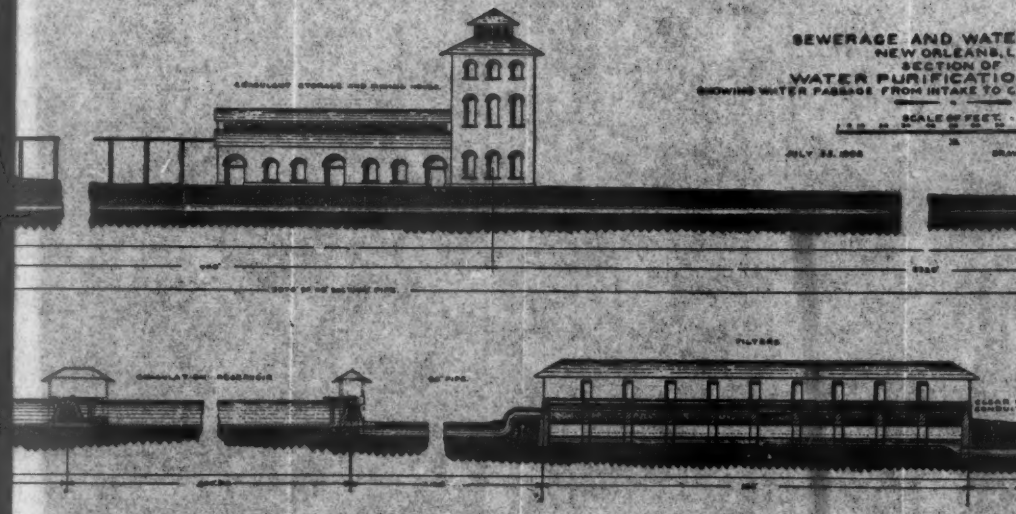
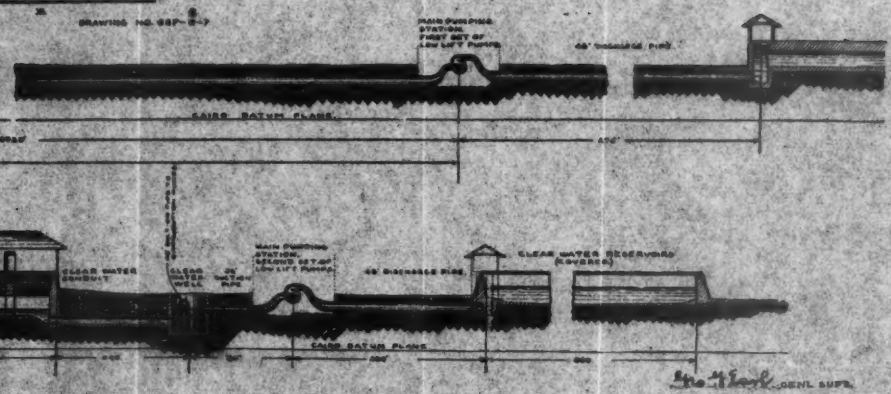

SEWERAGE AND WATE
NEW ORLEANS, L
SECTION OF
WATER PURIFICATIO
SHOWING WATER PASSAGE FROM INTAKE TO
SCALE OF FEET
JULY 23, 1908

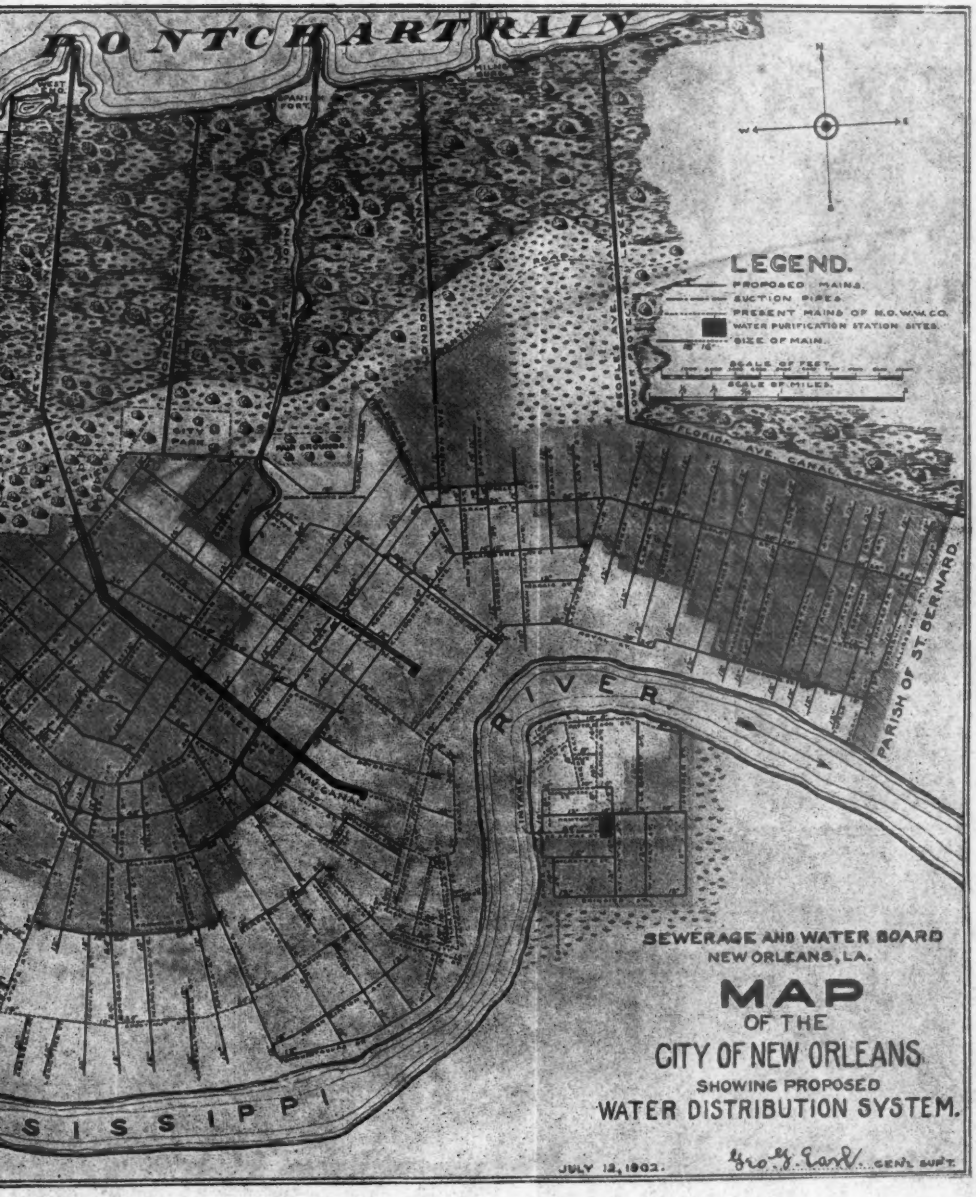
PLATE II.

AND WATER BOARD
ORLEANS, LA
ECTION OF
IFICATION PLANT
M INTAKE TO CLEAR WATER RESERVOIRS.



Geo. H. Earle GENL SUPT.

LAKE
BUILT UP AREA FOR IMMEDIATE CONSTRUCTION
UNBUILT AREA FOR FUTURE CONSTRUCTION DETERMINED IN PRESENT DESIGN
PARISH OF JEFFERSON
MISSI
DRAWING NO. 661-B-7


LEGEND.
PROPOSED MAINS.
SUCTION PIPES.
PRESENT MAINS OF N.O. W.W. CO.
WATER PURIFICATION STATION SITES.
SIZE OF MAIN.
SCALE OF FEET.
SCALE OF MILES.
FLORIDA AVE. CANAL
PARISH OF ST. BERNARD.
RIVER
SISSIPPI
SEWERAGE AND WATER BOARD
NEW ORLEANS, LA.
MAP
OF THE
CITY OF NEW ORLEANS
SHOWING PROPOSED
WATER DISTRIBUTION SYSTEM.
JULY 12, 1902.
Geo. G. Earl, GEN'L SUPT.

ILLUSTRATIONS.

The accompanying illustrations show a general plan and section of the experimental station (Fig. 1); ideal cross-sections of the experimental filters (Fig. 2); general view of American filters and controllers (Plate I); map of proposed intake, purificatiou plant, and pumping station (Fig. 3); general plan of proposed purification plant (Fig. 4); section showing passage of water through purification plant (Plate II); and map of the city of New Orleans, showing the proposed distribution system (Plate III).

DISCUSSION.

MR. L. M. BANCROFT. I would like to ask Mr. Weston what effect the coagulant has upon the hardness of the river water?

MR. WESTON. The coagulant has the effect of changing a certain amount of the carbonate into sulphate; it does not increase the hardness of the water or decrease it. It changes the chemical constitution of the matter which makes up the hardness, and makes the water slightly worse for use in steam boilers, but otherwise I do not think there is any appreciable effect.

THE PRESIDENT. We would like to hear from Mr. C.-E. A. Winslow.

MR. C.-E. A. WINSLOW. I have no doubt many members of the Association read this morning an editorial in the *Herald* on the typhoid epidemic which has just broken out in Ithaca, where, out of a population of 13 000, there are now said to be 340 cases of the disease. I notice that the writer, after speaking of similar experiences in Philadelphia and Chicago, adds: "But yet it seems quite impossible to make the people careful to drink no water which has not been boiled." I think such things ought to make us glad that we live in New England. It is an excellent thing, an admirable thing, that the necessity for boiling polluted water should be put before the public, but it seems discouraging that in some of our great cities the inhabitants must be continually on their guard to protect themselves lest the constituted authorities should neglect to do so.

I think we may pride ourselves on having passed that stage in this part of the country. Of course, eternal vigilance is the price of health, as the New Haven epidemic warned us a year

or two ago; but if you look over the statistics of typhoid fever in Massachusetts you will find that in practically every city and town the typhoid death-rate runs as low as it does in communities where we are certain that the water is absolutely pure — in communities, for instance, where the water is taken from driven wells and where there can be no possible contamination. And I feel that we have a right to draw from this the conclusion that very little typhoid fever in Massachusetts comes from our public water supplies.

Having obeyed the scriptural injunction to cast out the beam from its own eye, the New England Water Works Association is now reforming the country at large. The great work of the National Government under the Hydrographic Survey, in the study of the pollution of rivers, is in charge of Mr. Newell, Mr. Pressey, and Mr. Leighton, all trained in Boston; the new water supply for New York is being studied by Mr. Whipple, that of Philadelphia by Mr. Knowles and Mr. De Berard of this Association; the experiments for the water supply for Harrisburg are in the immediate charge of Mr. Hyde; and we have heard to-day of the great work in New Orleans under Mr. Weston's able charge. I think that all the members of the New England Water Works Association have a right to feel proud of these things.

THE PRESIDENT. We would like to hear from a Massachusetts man who lives up towards the New Hampshire line — Mr. Collins, of Lawrence.

MR. MICHAEL F. COLLINS. Mr. President, I did not expect to be called on to make any remarks to-day, but I will say this with regard to pure water, that in following up the typhoid statistics of the city of Lawrence for the year 1901 I found five cases on one spring-water route, all traceable directly to that one spring. Of course it would n't do to give the name; if I did I would get myself into trouble. When we come to find out how much typhoid fever there is in what they term pure spring water, and then compare it with our filtered water in the city of Lawrence, I feel that our city has reason to be proud of its filter. Last year we figured up our typhoid death-rate, estimating our population at 500 below what the State Board did, and found it to be 1 in 5 700. I think you will agree with me that is a pretty good showing, and

that we get good results from purification, considering we take the polluted water of the Merrimac River. In the year 1902, in a population as estimated by the State Board of Health of 69 000, and as figured by us of 68 500, we had 12 deaths. So I agree with what Mr. Winslow says — Massachusetts has reason to feel proud of its low typhoid fever death-rate, and especially so in Lawrence, considering our supply. At the present time our consumption of water has reached the capacity of our filter, but probably by another year we will have an addition to it, so we will feel a little easier than at the present time. If our President had informed me he was going to call on me I would have had some figures to present, but I am unprepared to say anything further at the present time.

A LITTLE TALK ABOUT WATER RATES.

BY JOHN C. CHASE, C.E., DERRY, N. H.

[*Read March 11, 1903.*]

Yielding in a thoughtless moment to the solicitation of our efficient Secretary, I consented to be responsible for a paper to be presented at one of the winter meetings of the Association. His sugar-coated privilege of selecting any subject of the many on which it was assumed I could speak with authority seemed to render the task an easy one, but the sober second thought "in the cold, gray dawn of the morning after" caused grave doubts of my being able to present anything of interest or value upon any topic. The late experience of that body of investigators known as the Committee on Private Fire Service — to curtail their title somewhat — suggested that something about water rates might be a novelty, hence the subject announced on the program of the day.

Next to a congestion in the supply caused by frozen hydrants or a limited rainfall there is, perhaps, no feature of water-works management that gives the average superintendent more concern than the one of water rates.

That they are a proper and legitimate charge goes without saying, whatever our socialistic friends may hold. That they should be equitably assessed on those benefited needs no argument. How the charge should be adjusted is apparently a question not easily answered, and one upon which widely divergent views are held, if the methods in vogue are any criterion.

Probably a great degree of the irregularity in the manner of assessing water rates is due to the fact that in the infancy of the business there was no simple, cheap, and efficient way of measuring with approximate accuracy the quantity of water used by the individual consumer. At the outset we are confronted with a condition appertaining, perhaps, to no other line of business, and conditions, like theories, are not easily gainsaid.

A goodly number in the average community are benefited only in an indirect manner by a public water supply. They may have undeveloped property on the lines of mains where no use of water is made, or they may be outside of the limits of the pipe system and get only an indirect benefit from the existence of a water-works system in the municipality to which they belong.

Now how can the burden be adjusted so as to be equitably borne by those benefited? The establishing of a proper schedule predicates the determination of the amount of revenue required. This should be sufficient to pay the expense of operation and management, interest charges on the capital invested, and create a sinking fund to cover depreciation of the plant and maturing interest-bearing obligations.

The amount necessary to be raised having been ascertained, it is next in order to settle what proportion shall be paid by the municipality as a whole, through the agency of the general tax levy. This compensates for hydrant service, and secures a contribution from those who are non-users of water but nevertheless benefited to a greater or less extent by the existence of the system.

What this proportion should be will vary in different communities and at different times in their history, and no hard-and-fast rule for determining it can be given. Inasmuch as the cost of a system to furnish efficient fire protection is largely in excess of the cost of one that would be of ample capacity for domestic supply alone, it would appear that a liberal portion of the amount of income required should be obtained by means of the general tax levy. The cost of additions to the plant should be treated as an increase of capital invested and not loaded on to the income account. Probably there is no better way of adjusting the proportion to be paid under this head than by a hydrant rental, which gives a tangible unit of measurement.

For all use of water in public buildings, for street sprinkling, sewer flushing and public fountains, useful or ornamental, the municipality should pay the same rates as any private consumer for like service, the water department being conducted strictly as a business enterprise.

Thus much for the municipality; now for the individual consumers. How shall they be assessed? Again a condition and not a

theory confronts us. In one city the family is made the basis of the rate, in another the fixtures, and with these two extremes there are complications and compromises galore. Of late years the water meter has been in evidence to quite an extent, although it is looked upon with disfavor by the consumer who desires to pay a fixed rate and have the unrestricted privilege of using all that he desires, which practically means that he is willing to pay only a minimum sum for a maximum quantity. It may be safely assumed that the consumer who objects to being supplied by meter either knows that he is using an excessive amount or has his suspicions that such is the case. Until that millennial time when the lion-hearted seller of water and the lamblike water taker are led captive by the innocent water meter, schedule rates will be in use as heretofore.

Looking upon them as a necessary evil for the time being, an effort should be made to have them sufficiently in detail to be reasonably equitable and yet not so complicated as to be unduly troublesome to adjust in actual use. From an equitable point of view it would appear to be necessary to take into account the number of rooms, fixtures and persons on the premises supplied. In some cities a still finer distinction is made, and the subdivision of "mealers" and "roomers" appears. The application of the personal numerical factor is complicated in Southern cities by the fact that the servants do not usually reside on the premises, and the claim is also frequently made that the rate should take cognizance of the fact that the family washing is not done "on the lot," to use the provincial term. The non-use for drinking purposes of the water supplied has also been the basis of a claim for rebate in the speaker's experience, and possibly may not be an uncommon experience in sections of the country where water cuts no figure as a beverage.

Until the respected head of Harvard University and his followers have met with a pronounced degree of success in their campaign for larger families, it may be as well to pay no attention to this factor in establishing the domestic water rate, for at the present time the average American family rarely exceeds the limit usually established by water departments. The number of rooms in the house may also be ignored. While it is true that more water would naturally be used in taking care of a large

house than a small one, yet the inequality is corrected to a great extent by the proportionate amount of the general water tax paid by the larger establishment. That a charge should be made for duplicate fixtures appears to be beyond dispute, for it is certain that they facilitate the use of an increased quantity of water, to say nothing about the chance of leakage, which is responsible for the loss of a large proportion of the water supplied in the average city.

The simplest schedule rates that I have seen are given as a matter of personal experience. A basis charge was made for the initial fixture of each class for a family of five persons. Additional fixtures were charged from one to two dollars per year according to the class. For each person in the family in excess of five, ten per cent. was added, which made the rate elastic enough to cover the case of boarding houses. For all other consumers meters were required, with a mimimum charge of ten dollars or more per year, according to the size of the meter used, and any schedule water taker could have a meter if that method of payment was preferred. The water company supplied the meters and kept them in repair, the consumer paying the initial cost of setting and boxing. At the present time about two thirds of the services are metered, being practically all whose annual rate would exceed the mimimum meter rate.

The custom in some places of not permitting the use of meters on residence services is condemned as an arbitrary exercise of an assumed right to oblige one person to help make good the loss occasioned by the willful or negligent acts of another.

There is another class of customers whose rates and privileges have received an inordinate amount of attention in the past few months. It is hardly necessary to say that reference is made to the "fire service" rates. Notwithstanding the more than ample consideration of this subject, it is still unsettled and can hardly be ignored at the present time, although any allusion to the matter may prove to be an apple of discord. As premised at the outset, the supplying of water for fire purposes is made a function of the municipality, and the proper proportion of the water department expense met by general taxation. The regular fire department stands ready to flood the premises of the individual consumer should occasion arise and the supply be sufficient, and the

actual loss from the water used often exceeds that caused by fire, because of the necessarily inefficient and often tardy way in which it is used. Now if the consumer chooses at his own and not inconsiderable expense to equip his establishment with the means of more quickly and efficiently using the self-same fluid that belongs to him by right, why should he be obliged to pay for the privilege, especially as he is more than likely to reduce the actual consumption of water to a large extent? The only answer, to my mind, that carries any weight is that he cannot be trusted to make no illegitimate use of the opportunity to divert the water for other purposes. Granted; but I am inclined to consider it an insult to our American intelligence if some means cannot be devised by which those who are disposed to "tote fair" may be relieved from the system of double taxation to which they are now subject in many cases. As a matter of course, the consumer would be required to pay any extra expense incurred by the water department in giving him the desired facilities and the installation and inspection of any apparatus designed to prevent or detect the unlawful use of water. Inasmuch as the actual use of water for the extinguishing of fires in a manufacturing establishment would be but a small proportion of the total amount used in a term of years, it would work no hardship if the whole supply were taken through a meter, thus entirely eliminating the inspection feature. Of course, this idea will not meet with the approval of the insurance companies, but "that is another story," and having enough "troubles of my own," I pass their grievance by.

But I imagine some representative of a water company saying, "That course of reasoning is all very well where the water works are owned by the municipality, but we are in the business for profit, not pleasure or health." The fundamental principle is the same. When a water company contracts with a municipality to furnish water for fire purposes it stands in exactly the same relation to the consumer as a municipal water department.

As before stated, the water department should be conducted as a business enterprise. Churches and eleemosynary institutions should pay the proper charge the same as any other consumer. Those who buy water by the thousand gallons and sell it by the quart, like the rectifier, brewer and the dispenser of "soft drinks," or the manufacturer who reduces his insurance by the introduc-

tion of a sprinkler system, are all on the same plane with the ordinary consumer. It is water alone as a raw material with which we have to deal,and while it may be considered a privilege to have it at our disposal, the only measure of its value, under existing conditions, is the quantity actually or presumably used.

FUEL: WHAT WE DON'T KNOW ABOUT IT.

BY EDWARD ATKINSON, LL.D., PH.D., PRESIDENT BOSTON MANUFACTURERS MUTUAL FIRE INSURANCE COMPANY.

[*Read March 11, 1903.*]

Gentlemen, — I claim no exact knowledge of any of the physical sciences. My attention has been called to what may be called the principles of combustion only since it became my profession to make the prevention of loss by fire an applied science. What I may say to you will therefore be the result of observation coupled with such smattering of science as one must pick up who is obliged to select scientific experts in all branches of physical sciences, and who must make an effort to understand their work in order that he may make it plain to the managers of the factories.

Perhaps the greatest waste of a wasteful people is the waste of fuel. Certainly the most wasteful example of modern mechanism is the steam plant, consisting of boiler and engine. The best results claimed in this country for the most perfect boiler and engine plant is the conversion of less than twelve per cent. of the potential of the coal into work. A little more is claimed in Great Britain, but I have seen no evidence to convince me of the fact. The locomotive and marine engines are far more wasteful, and yet in the marine engine a cube of the compressed and dried mud which we mis-call bituminous coal, which will pass through a ring of the size of a quarter of a dollar, will drive one ton of cargo and its proportion of the steamer one mile upon its way by the conversion of only five or six per cent. of the potential of that little cube into the work.

It is computed that out of 250 000 000 tons of bituminous coal mined last year 85 000 000 were consumed in locomotive boilers on railways, in which not over five to six per cent. of the potential is converted into work, or about 5 000 000 tons.

Compare this waste with the turbine wheel, which Boyden

carried to such perfection as to utilize more than ninety per cent., I believe ninety-five per cent., of the potential of the water in a wheel of so fine a character that in order to keep it up to its work the guides needed to be often scoured with a crash towel to remove the slime left by the water.

The electric dynamo is another example approaching perfection. More than ninety per cent., I think, more than ninety-five per cent., of the power applied is converted into work.

The generation of power from coal is worked by combustion, converting the gases of the coal into what we call heat. Heat is a form of physical energy, said to come directly from the sun. I venture to suggest that this is an error. If the vibrations emanating from the sun brought the energy of heat directly to the earth, then the tops of the mountains, especially in the tropics, where the highest mountains are, would be the hottest places in the world and the deep valleys would be the coolest or coldest. The reverse happens to be true. How, then, is heat generated from the sun upon the earth? It is of course known that the whole body of the sun is in a state of intense incandescence. The photosphere is disclosed by the spectroscope, consisting of all the known substances, metal, mineral, and the like, in a gaseous condition. From this body emanate immense vibrations passing out into the ether of which we know little or nothing. As these vibrations, undoubtedly of intense heat, pass beyond the direct influence of the incandescence of the sun, must they not become intensely cold until they approach the earth? Otherwise why would the outer atmosphere be cold and the tops of the highest mountains, even in the tropics, be covered with perpetual snow? It is only when these vibrations come down into the lower atmosphere or strike the earth itself that heat is generated. How? Is not the heat generated by friction, the fricton of these vibrations or undulations forcing their way through the more dense atmosphere after having passed through the ether? Where these vibrations or undulations strike vertically, as in the tropics, heat may be generated not only by the friction of the atmosphere but by the concussion with the more solid earth, while in the temperate and frigid zones these vibrations striking at a more and more obtuse angle make less concussion or glance away into space without promoting the excessive friction and heat of the tropics. ¶ I

do not know whether this theory will stand among scientific men. It may be in the books, and if so, I wish I had the citation. So far as it goes, it is a hypothesis of my own; not consciously derived from reading. From that heat generated by the sun we of course derive the possibilities of life, the growth of plants, the formation of mud ultimately converted into coal. The sun is the primary source of heat; friction and concussion the secondary sources.

What, then, is coal? Again I must deal with my slight knowledge of geology. We live here upon the spurs of the great Laurentian chain, called in the United States the Appalachian chain, the oldest rib of the continent. It consists of the igneous or crystalline rocks, which have been converted by heat into granite, gneiss, and the like. They are without fossils or organic remains, but contain potash and other elements of fertility in very large measure; the granite is pervaded with fossil water in hygroscopic form, which renders it so bad a resistant against fire. The small particles of hygroscopic water, being converted into steam, rend the granite into sand; so that in the basement of one of our factories where there were alternate oak and granite posts exposed to a very hot fire, the oak having been put in to supplement the granite, the latter were completely destroyed, while the oak were carbonized only to the depth of an inch, holding up the building and saving a large loss.

We know little of the contour of this primal continent. We do know that it was flanked on the west by the extension of the Gulf of Mexico as far north as the blue grass section of Kentucky, and that the outlet of the St. Lawrence was once in that direction. We know that the ocean of that period was of very different chemical quality than the present ocean — far more corrosive. The authorities of the Boston Gas Company once consulted my old friend, Prof. T. Sterry Hunt, on the expediency of making an artesian well at the North End in order to avoid the heavy water tax which they paid on their steam plant. He told them that in this formation they might strike water, but it would be fossil water of a certain chemical quality, which would be utterly useless for a steam plant because of its corrosive quality. They were not discouraged. They put down the well; they struck the water, and it corresponded in its corrosive action to the theory of Professor Hunt. This water ate away the granite and the gneiss

until gradually a soil was formed. Then followed the period of the coal measures, when plant growth of the most profuse kind passed year by year into partial decay, protected from total conversion into gas by being buried under water. This plant growth consisted of the carbon and the hydrocarbons derived from the atmosphere, and the albuminous or nitrogenous elements derived from the soil. Year by year, as one plant succeeded the other and the other was buried in the mud, the anaërobe microbes which thrive in water, but are killed by exposure to the air, fed upon the albuminoids, converting them back in the process of decay into gases and restoring them to the atmosphere, while the carbon remained, hence the will-of-the-wisp, marsh gas, etc. All this change to coal must have taken place under water in the form of mud, because when vegetable matter falls upon the surface of the ground after one set of insects and microbes, known as aërobes, which pervade the air, have disposed of the albuminous and nitrogenous parts of the plant, another set of microbes attack the rest of the decaying mass, carbon as well as other portions, and convert the whole back into the gases from which the carbon was originally derived.

The deposits of coal are not confined to the carboniferous series or era. The great deposits of that period, consisting of the anthracite, the semi-bituminous and large deposits of the bituminous coal, were subjected to the great disturbance of the shrinkage of the earth's crust. The anthracite coals were subjected to an enormous pressure, which rendered volatile the hydrocarbons and left the fixed carbon, from ninety-two per cent., sometimes ninety-eight per cent. of the whole volume. The semi-bituminous coals, and the best bituminous coals, those known as coking coals, were subjected to a less measure of pressure and to a less degree of heat; they retained the hydrocarbons which are mis-called bitumen, yielding the qualities which are so well known. But as we pass west into the more recent geologic periods, we still find the process of conversion of plant life into mud and then into coal, yielding the almost level deposits of the coal of the middle West, which has been subjected to a light pressure, is friable, dirty and smoky, covered in many places by the loess, or wind formation. But not yet the end. When we reach the far West, the youngest and vol-

canic section of the country, here again we find that plants have grown and decayed and have formed what is known as lignite or brown coal, which in the volcanic uplift has been brought to or near the surface, the water draining away, leaving it a friable, carbonaceous material, containing twenty-five to thirty per cent. of water in the hygroscopic form, and when compressed into briquettes making a good fuel. Lignite is nothing but fossil mud.

Again, all over the Southern states, Alabama, Mississippi, Louisiana, and Texas, where for geologic ages must have been great mud lagoons while the water was receding, there are immense lignite formations from which there may be hereafter derived a clean, smokeless household fuel, possibly or probably without the necessity of adding any tarry or bonding material to the lignite. That is a question of mechanics. But we have not come to the end of the coal and lignite measures yet. We may now come back to the modern period, the alluvial, and again we find plants growing, decaying, forming great, deep bodies of mud protected by water from the destructive organisms of the air while the anaërobes are consuming the nitrogenous portions, converting them into gas which bubbles up in the bogs, marsh gas and the like, passing on for conversion and reconversion throughout the ages. All things have been gas — all things will be gas. That process is going on in Massachusetts over great areas; and here is probably the first specimen of mud — clean slimy mud, much more free of fibers than peat — which has ever been converted into fuel from the mud of the sluggish Taunton River, or from any other mud in the United States, although the peasants of Ireland have been making and burning mud briquettes for generations.

This parcel represents mud fuel dried by Professor Norton by artificial heat and very slightly compressed. It has a potential higher than that of hardwood or the best of peat fuel. A parcel of fifteen pounds placed in an open grate on a brick floor outside of any fireplace, and lighted with some paper, yielded a clear, blue flame about a foot and a half high, with very little smoke, a very strong heat, and burned out in about an hour and a half leaving a considerable volume of very fine ash, of which the proportion is larger than we expected. This ash probably consists of dust that has blown in upon the surface of the bog, or possibly of the siliceous coverings of the grass which do not decay.

The way in which I happened to turn my attention in this direction may interest you. We were at my summer place at Mattapoisett, on Buzzard's Bay, when the coal strike took place, and although I had fortunately laid in a full supply of coal in Brookline, I began to look around for emergency fuel. I went out into the woodland on my place, consisting of hardwood, where dead leaves and a very vigorous growth of ferns had been decaying upon the top of a glacial drift; dug up some sod, finding from one to three feet of black humus or decayed vegetable matter underneath; took the sod into the kitchen and placed it in an iron pan to dry off. My Irish cook said, "Are you going to burn it, sir?" I said, "I am going to try to." "Oh," she said, "that would make a fine back-fire if it had been out in the sun and air to dry awhile." I said, "What do you burn in front, peat?" "No, sir, not in my part of the country. We burn turf. Turf is the black mud, sir, that comes under the sod. It is dug out and worked in a trough like a bed of mortar; then made into blocks, spread out in the sun and air for a few weeks, and when it cracks it is ready to burn. It makes a very hot fire."

This account has been confirmed by two other very intelligent Irish women, one of whom, hearing me talk about it in the electric car, asked leave to say a word, saying that she was so glad to hear some one talking about turf. "There 's millions in it, sir, if you go at it in the right way. There 's turf around my place in Newton to heat the whole county, and nobody seems to know anything about it." She also made the distinction between turf and peat, and this accounts for the stories that have long been told of the bursting of peat bogs in Ireland, overwhelming farms and valleys. The peat bog, as we know it, is in a hollow. The specific peat plant, as we know it, is the sphagnum moss. None of these bogs could burst and overwhelm a neighborhood, because they are always the lowest point in that neighborhood. In point of fact, in the very humid climate of Ireland, what has sometimes been referred to as "grass peat" forms with great rapidity upon the slopes of the hills, yielding both the sod and the turf to which reference has been made, and when after very heavy rain this black mud becomes saturated, the sod bursts and the mud pours down the slope of the hill.

In Germany, where the greatest progress has been made in the

conversion of peat into briquettes, the common name is "*Torf.*" A very large part of the smokeless fuel of Germany is derived from peat or torf, or from lignite or fossil mud, both being converted into briquettes, usually with a slight admixture of mineral tar or pitch to bond them. Consul-General Mason's reports give minute accounts with diagrams and descriptions of the machinery used. I observe, however, that the mechanism described is almost identical with mechanism which I invented in 1867 for converting peat into briquettes at the Indian Orchard Mills. The price of coal in that paper money era being very high, we successfully worked a peat bog for many months in a boiler plant of mills of about thirty thousand spindles, giving it up when coal went back to normal prices. But what we call peat, which is very full of hollow fiber and of the fibers of the grasses that grow on the top of the moss preserved in the peat, is very much more difficult to compress, and takes much longer to dry than this slimy, nearly homogeneous black mud from the Taunton River. Professor Norton is now having a small machine made on my original plan for the conversion of the mud into briquettes, and we shall, ere long, be able to turn out a sufficient quantity for a more complete test, with some approximation toward the cost of the work.

But there is another aspect to this case, namely, the conversion of meadow mud into gaseous fuel. That is now the direction of all invention. The gas engine will, in my judgment, wholly displace the stationary steam engine within a short period of time.

Recent inventions in the conversion of the slaty culm of coal into gas, called the Mond gas process, may tend to a solution of this question. It has been necessary in Great Britain to utilize what had been waste products of the mines more fully than we have. In fact, the low price of our coal has retarded invention in this country. By the Mond process, now taken over and being introduced in this country by R. D. Wood & Co., of Philadelphia, culm, no matter how slaty or dirty, if it contains a certain quantity of coal, can be converted into gas. The crude material is subjected to a lower temperature than by former methods, so that the gas is dissociated, as I understand the case, without melting the refuse slate or other material, and converting it into slag or clinker. Possibly this process may be applied to meadow mud even without complete drying. It occurs to me

that the mud may be reduced in its water content until what remains becomes in a measure hygroscopic, and not exceeding the proportion of water required in the manufacture of water gas from anthracite and water. If this proves to be feasible the finely divided or hygroscopic water combined in the carbon of the mud may be more readily dissociated and mixed with the gases of the carbon than it could be by any other process.

All this is hypothetic. The only claim which I make is to having called attention to what seems to me a great fact, namely, that the mud in the fresh and salt water meadows as well as the peat in the peat bogs may now be regarded as a vast source of energy, requiring for its conversion into heat mechanical appliances rather than any other, so as to bring the material into a semi-solid shape or into gaseous form, in which it may be converted into heat and power. If all this proves to be delusive, I have no scientific reputation at stake, and may have lost nothing in repute for having started in a purely empirical way to develop the subject. On the other hand, if the difficulties can be surmounted at a cost that will relieve the increasing scarcity of anthracite coal, only to the supply of household fuel; or if it shall prove feasible to convert this vast store of energy, or, as we may call it, coal in its primary process, directly into heat without the lapse of geologic ages, then I may have added a benefit to society which will be worth remembering. I may then receive a compliment similar to one which I received on the Aladdin Oven, "So simple that nobody but a fool would have thought of it"; or like one given me on his first vision of the diffusion of light by ribbed glass, by a distinguished oculist, who exclaimed, "Why did not some donkey ever think of that before Atkinson?"

*After I had made this record and thought that I had come to the end of it, information began to fall in from every point. A German in Portland, Ore., referred me to Brockhaus "Conversations-Lexicon," the latest edition. As I do not read German, my son looked up the matter, and I am again impressed with the fact that our abundance of coal has kept us very far behind in the way of useful inventions developed from peat, not only in the matter of fuel, but its application to many other purposes.

There are three varieties of peat, of "torf," as it is called in

*The following matter has been added by Mr. Atkinson since the paper was read.

Germany, each varying greatly from the other, and all applied to useful purposes : —

The "heath moss turf" moor or highland peat, growing on high uplands, consists of the partially decayed remains of the heather, of broom, of cotton grass, so-called, and varieties of sphagnum moss which require no water.

Then comes what is sometimes called grass peat, like that made from the banks of Ireland; the black or dark brown peat, mainly decayed grasses and the weeds that grow among the grasses.

And, lastly, the peat of the regular peat bogs corresponding to our own, consisting chiefly of the sphagnum moss and of the water plants.

The surface heath moss turf has very little value for heating purposes. It has great absorbent power. When saturated with rosin it is converted into kindling. It is made in various compounds into paper, carpets, "mossturfstone" for partition walls, packing material, especially for meat and drink, beer glass stands, carpet linings, fireboards, sound dampers, steam pipe coverings, boards for insect collections, stuff for bandages, and filling for mattresses and bed cushions for the sick. The peat cotton grass yields fiber that is spun into garments and horse-blankets. The black torf below is made into fuel.

The grass peat or torf made from these deposits is burned not only in Ireland, but all over Holland, Denmark, and many parts of Germany and other European countries, where it is practically the only fuel. In Germany the yearly consumption is rated by the million tons. In agriculture the moss turf layer of the highland moor and the sod of the grass turf layer occupies a very important place. For certain purposes it is thoroughly dried and ground into peat meal, which will soak twenty-five times its weight of moisture. It is then used to take the drainings of the stalls, to mix with the straw refuse of the stables, and, when mixed with a little "Kainit," one of the products of the Stassfurt potash mines, it retains the volatile elements of manure. Its further advantages are that it assures a pure stall air and healthy bed. It prevents animals from eating the rotten straw, it also absorbs grease and gases. It is a great deodorizer in ditches or barrel contents. By the addition of two per cent. of sulphuric acid it becomes destructive to the cholera and typhus bacilli with-

in twenty-four hours. In several German cities peat meal at the rate of about two hundred grams per day for each inhabitant is mixed with the collected sewage. In Hamburg I observed that disinfectants were scattered on the streets before the watering carts. It is used in composting the waste of the sugar factories and the refuse of slaughter houses, and, as I have previously said, for packing eggs, meat, fruit, and the like. It is said that sea fish packed in peat meal have been found still good after eighteen days.

Shortly after my mind had been turned toward the discovery of an emergency fuel, and I had made my first experiments on turf, I happened to make a tour of observation in the West among the great agricultural tool works and others which we insure. On my way I observed the enormous waste of corn stalks, on which Professor Norton had already measured the heat units for me with a view to compressing the corn stalks for fuel. With each crop, approximating seventy million tons of shelled corn, there are at least one hundred million tons of stalks, leaves, and cobs, of which not over one half is yet shredded or saved in any other way for fodder; the rest encumbers the field. It occurred to me that there would be no difficulty in compressing this material immediately after shelling the corn, which is now done by machinery without removing the ear from the stalk. At that period the saccharine is not fully dry and might therefore serve as a bond, but on further reflection it seems that sorghum, which is more reedy, and contains a larger measure of saccharine, could be grown for fuel at very light cost. On good land it will produce ten to fifteen tons dry weight per acre at a cost of only one dollar to one dollar and a half per acre for the planting. If then a cheap and effective press for farmers' use could be made, every farmer could grow his own fuel on one or two acres of land out of a farm of one hundred and sixty acres; and, if the ashes were saved and spread upon the field for the next growth of leguminous or nitrogen-gathering plants, the farm could be improved by the process.*

* Since this was sent to the press a Western machinist of large capital has presented plans of a very simple press for making a cylindrical bale of cotton by rolling laps, differing from the presses now in existence, and capable of being made on a small scale for farmers' use in rolling sorghum stalks into logs, say four feet long by eight inches diameter. On calling the attention of the inventor and promoter to this great field, he became much interested, and said he would take the subject up and work it out to test its feasibility as soon as the present crop of sorghum should be in condition.

This project appeared to be a very simple one to several of our Western clients, who will take it up. One, the head of a large agricultural toolshop in Rockford, Ill., goes further. A box is on the way containing the roots of the corn plant, which are now an absolute waste and encumbrance, his computation being that the roots from five acres of corn might serve for a year's stock of fuel for the average farmer and that these could be piled away after harvesting, to be worked up during the winter months by cutting and compression.

Whether these visionary suggestions of growing fuel in the West and working mud in the East may become burning facts is, therefore, a merely mechanical problem. At the present time my scientific friends are more sanguine of success than I am.

Since compiling this information from public documents, others have been sent to me by Consul-General Mason, of Berlin, — one describing a very recent invention of the Zeigler apparatus for converting certain varieties of peat, especially that from the peat moor, into coke and many secondary products. The extent of these peat moors in Friesland, Sweden, Germany, and other parts of Europe is something of which we have probably little idea. In Friesland colonies have been planted on the peat moors as far back as the fourteenth century, to clear arable land from the encumbrance of this peat, while in Germany the work has also been undertaken for the recovery of the land, which has now apparently become of secondary importance to the conversion of the peat.

The Zeigler process was invented in 1895 by one of the eminent German chemical engineers. It has been thoroughly investigated on behalf of the Russian, Swedish, and German governments; has been approved, and is now coming into work in various places.

The peat moor yields machine peat, that is, briquettes, from which are derived: —

Coke, for use in metallurgy, equal to charcoal.

Heating coke, which gives flame, and from which all the hydrocarbons have not been driven off.

Crude tar, from which are derived: impregnating tar, paraffin and gasolene, tar water, yielding ammonium sulphate, methyl alcohol, and other products.

Volatile products: power gas, lighting gas, and heating gas.

Secondary products: peat straw, peat meal, and peat wool — leaving the land in excellent condition for cultivation. The peat meal mixed with the molasses of the beet sugar factories makes a valuable food for cattle. It is also used as a non-heat covering for ice and as a covering for compost heaps to save the escaping ammonia.

In the coking process gases are thrown off from the volatile hydrocarbons, which are then used for heating the ovens, and may be used in gas motors.

The upper layer of the moss peat is converted into the straw and meal to which I have previously referred. It is said that from the production of 22 000 tons of peat briquettes, 600 tons of the wool fiber are yielded.

Elaborate figures are given of the cost, but as these are based on German wages and the work is largely handwork, they may be of little service to us until we may substitute mechanical processes for the handwork of Europe, thereby developing high wages and low cost.

The geographers will know whether we have any of these high peat mosses in this part of the country. We have something which must closely correspond to them in Alaska. I have long attempted to keep the track of the developments of new gold fields, anticipating a considerable depreciation in gold, which I think is already manifest. The latest discovery has been at Cape Nome. From the gold-bearing beaches rises a crest, then a depression, and back of that depression for a distance of more than one hundred miles in length, and twenty or thirty miles wide, is what is known as "the tundra," corresponding to the tundra of northern Europe, — a level plain, covered with two to three feet of the moss and other plants. Under this for many feet in depth are sands corresponding to the sands of the beach, and in sections of great area, justified by the geological reports, are great beds of gold-bearing sand, in which the fine gold is held throughout the mass. A large section of this has been taken up by a company of which a large capitalist of high repute, well known to many of you, is the chief promoter. He has been on the ground all winter with large amounts of machinery, ready to set up this spring and to begin taking out and washing this sand by scien-

tific methods. The scarcity of fuel is one of the main difficulties at this point, and if the tundra can be converted into fuel by the process described, another step will have been taken in cheapening gold, or, in other words, in raising general prices.

I have thus laid before you the most visionary scheme that could enter the mind of a practical man. In all these investigations of peat and turf it never seems to have occurred to any one that the deep black mud of our fresh-water swamps, by our sluggish rivers, or of our great areas of salt marsh, must be substantially of the same composition, and may yield similar products. I was forced to make a premature publication on this subject because I suspected a purpose to cut in with some piratical patents that might have been embarrassing — my own previous publications of inventions in automatic sprinklers, ribbed and prismatic glass, automatic fire doors, and for measuring the heat developed on heavy bearings having already saved my clients heavy royalties and obstructive litigation.

I will merely add one more element to the light that I have attempted to derive from mud. What with lignite, mud, cornstalks, sorghum, bog peat, and moss peat, we may tide over the present period of our ignorance during which we must secure light and heat from these crude materials, including coal, awaiting the invention of the perfected storage battery, by which we may soon be able to supply all our domestic fuel and light by the storage of wind, especially on the Heath Hill; while other less favored dwelling places will derive their light and heat from the fall of water or the rising of the tides.

I had but completed this analysis of the Zeigler process when in came one of the earlier graduates of the Institute to consult me on how his son, also a graduate in chemical engineering, now taking a post-graduate course in Berlin, could best introduce the Zeigler process in this country. Surely all things come to him who waits.

ADDENDUM.

At the date of correcting the proofs of the foregoing, June 4, 1903, I may record additional progress. A little group of Swedes, possessing very little money, have for five years been making a physically strong coke from the salt marsh peat of Connecticut, on one of the channels subject to the ebb and flow of

the tide. This grass peat, as it may be called, is spongy, porous, and full of roots slightly decayed, probably preserved by the salt, also containing a large amount of fine sand brought in by the tide; and yet this material is compressed and converted into a physically strong coke, which burns freely for domestic purposes, and although it contains thirty per cent. of sand its heating value is equal to sixty-five per cent. of that of good bituminous coal. Persons with capital have taken hold of this matter and will develop it.

Again, Professor Norton has made physically strong and excellent coke in the laboratory of the Insurance Engineering Experiment Station from uncompressed, air-dried Taunton River mud. Of course, the uncompressed mud being somewhat friable, the coke is delivered in small pieces from the size of a pea to the size of a walnut. When compressed, as it soon will be, we expect to make large blocks of excellent coke from this mud. As yet, the retorting process has been conducted in a piece of iron pipe, stopped at the ends, with a vent for the escape of gas. We have tested this gas with a gas burner, and find it a high-power illuminating gas, therefore capable of yielding all the secondary products of gas.

The mechanism for pulping this mud and bringing it into condition for very rapid drying is complete. Retorts will soon be adapted to our purposes, and within a short time we may be able to get an approximate estimate of converting fresh water mud into coke, gas, and secondary products.

We have now examples of mud from three points, representing bogs which, according to our minimum estimate of tolerably well-known areas and depth, contain several million tons of coke, which may be worked out from the mud at a low cost if the estimates based on laboratory experiments can be established in commercial practice.

Engineers who may have struck large bogs of mud in connection with the construction of reservoirs may perhaps ere long desire to have such deposits analyzed and reported upon. Measures will be taken to this end by Professor Norton at such charges as will reëmburse the Experiment Station for doing the work.

Professor Norton suggests a very simple plan for testing any sample of marsh mud in an improvised retort:

Select a section of one and a half or two inch steam pipe, eight to twelve inches long; fill in with air-dried mud as compact as it may be made; plug the ends with clay or asbestos left loose so that the steam and gases may escape; place underneath three gas burners, Bunsen burners preferred. It might be possible to heat the contents of the pipe over the fire in an ordinary cooking stove, but the gas burners may be more readily managed Test the burning quality of the gas at the ends when escaping.

I may suggest that it would not be a difficult matter to compress parcels of mud into cylinders of less diameter than the pipe. The coke of these compressed parcels would be in larger pieces, probably less friable than any that can be obtained from uncompressed air-dried mud.

Any person slightly conversant with laboratory practice may apply this test to deposits of mud that happen to be in the neighborhood. It is much desired that the experts in the Agricultural Experiment Stations, to all of whom this report will be sent, will test the meadow mud or "grass peat," as perhaps it had better be called, in their respective neighborhood. We shall be glad to receive reports of results, and if possible some idea of the areas and quantity that may be available for future conversion, if the processes of the laboratory can be developed in commercial practice. It is held that the area of what we have called mud bogs yielding grass peat is vastly greater than of what are customarily known as peat bogs yielding the partly decayed matter mainly derived from sphagnum moss and the water plants which grow on the surface of such bogs.

Reference may also be had to an article in the *"Nineteenth Century"* magazine for May, by Lieut.-Gen. Sir Richard Sankey, K.C.B., R.E., upon the conversion of the great bog of Arran and other Irish bogs into gas and electricity for restoring the manufactures of Ireland, many of which were destroyed by the tariff policy of Great Britain, which prevailed up to 1842, by measures corresponding to those by which the effort was made to prevent the establishment of manufactures, metal work, and the like in the colonies of America. The suggestions of Lieut.-Gen. Sir Richard Sankey are limited to the production of gas and of electric power therefrom. He does not yet appear to have

realized the possibility of making coke from the peat or mud contents of the bogs.

DISCUSSION.

VICE-PRESIDENT BROOKS. We have listened with great pleasure to Mr. Atkinson's paper, and if any member wishes to ask him any questions I am sure he will be glad to answer.

MR. CHARLES N. TAYLOR.* I was out at Lexington or at East Lexington the other day, and I noticed the pumping station which was used, I think, by Arlington before it came into the Metropolitan District; it is a very nice building, and I remarked to the superintendent of the Lexington works that it was too bad that such a nice building should be lying idle there without being put to some use. He said, "Well, they are going to use it, they are going to start a new industry here." Said I, "What is it?" He said, "You see this meadow all out through here," — that is where they had their driven wells, a large area, I should think there may have been twenty-five acres, a peat bog, it looked like, — "they are going to cut that peat and take it into the pumping station and press it into briquettes and sell it for fuel." That is the first I had ever heard of any such industry in this part of the country.

When I was in Scranton, Pa., this winter, I ran across a man with sample briquettes from Germany, and he had these reports of the United States consul to Germany and was circulating them He was organizing a company to make briquettes of this fine waste material which comes out of the mines, and which is piled up mountains high in front of the mines, and has never been made any use of. But in reading over the report of the United States consul to Germany I thought he spoke rather discouragingly of its being a profitable scheme in this country, owing to the expense of the material which had to be put with the peat or coal dust in order to bind it together,—I think it was tar or something of that nature.

MR. ATKINSON. I am very glad to know where that undertaking is going on in Arlington, as I want very much to get some of those briquettes. The conversion of coal dust into briquettes is very common in Germany, but it requires a bonding material.

* Wellesley, Mass.

There were at one time some very large undertakings in Virginia for converting coal dust into briquettes, but for some reason or other they thought it necessary to put a little light naphtha or kerosene oil into the mixture, and on the rise in the price of naphtha their profits went out. I have come across various undertakings for getting up and introducing companies of the get-rich-quick kind in connection with this matter. Now, why I have come out prematurely is, that I want to cut off all that sort of rubbish. Mr. Norton and his assistant and myself are convinced in our own minds that we can convert this mud into briquettes of sufficient hardness and durability to be excellent fuel, by a purely mechanical process, and there is the crucial point. If we can, why then we have done it. If it requires a bonding material, there is more refuse material, tank-bottoms and the like, in this country than in any other, and we may be able to get a bonding material which is now wasted, at such an exceptionally low cost that we will be able to use it.

The main object in bringing this subject before you gentlemen is to set you all thinking about it, and to get lots of heads at work. I am nothing, as I tell you, but a "duffer," but I want to see if I can't cut off some of these piratical bottom patents on the conversion of mud. I have had to meet these piratical patents three or four times, and I have saved my clients a lot of money on sprinklers by having made an invention and publishing it a year before a patent was granted on one little element which went into all sprinklers. I smashed one piratical patent on the diffusion of light, and I am engaged to-day in smashing another because I anticipated it and published it. I have found in my practice that neither expediency nor the conditions of my profession will permit me to have any patent, and therefore we are very careful in the office to publish every little device. I invented the sliding automatic fire door which is now in universal use, and published it and got a silver medal, and had it put on record, or else I would have been cut off on that. I invented the proper way of taking the heat of a revolving shaft in the simplest possible manner and published it, and two years later a fellow came in with a patent on it and I "busted" that. My object now in this premature discussion is to cut off these get-rich-quick fellows, and start one thing on a solid basis of science and fact which has some merit in it, perhaps.

MR. FREEMAN C. COFFIN.* I don't know that Mr. Atkinson is aware how appropriate this subject is for a meeting of water-works men. If we will just let our imagination loose for a few minutes we will see what can be done and what boundless possibilities are open to the water-works engineer, and how it will change the conditions under which he has got to work. We now go about the country looking for a storage reservoir, and we find a very nice place, well adapted in every way, but the mud is all the way from a foot deep to twenty feet deep, and when we find it twenty feet deep that rather discourages us. We cannot take it out at any reasonable cost, and we don't dare to store water on top of it. All we have got to do hereafter is to set up one of these little machines, — perhaps we will be able to do it next year, — make the mud into fuel, store up all the fuel the works will want to use to pump water with for years to come, and sell the balance for enough to build the works. [Laughter.]

MR. ATKINSON. You are a more visionary fellow than I am. [Laughter.]

MR. COFFIN. I am looking forward to the time when we can build water works for very much less cost than at present, and this is right in that direction. And then when we get so that by imitating Marconi we can construct our distribution system on the pipeless plan [laughter],— I don't see what there is to laugh at; it seems to me it is a very serious matter. But certainly it is going to help us on our storage basins if mud fuel turns out as we hope it will.

MR. ATKINSON. My little machine which I used at Indian Orchard and afterwards turned over to the late N. W. Farrell, and which he used for two years down at Lewiston, was a very simple one; anybody can have it made. It consisted, as I remember it, of a large cylinder about two feet in diameter, with a spiral alternating little plow shears and little knives on the straight sides, and it had a hopper at the inner edge. Then at the other end was an Archimedian screw without any knives or plow shears, and we put in an endless belt, and brought up the peat from the bottom of the bog, poured it into the hopper, turned the machine, and that ground it and pulped it and released the water. Then the Archimedian screw drove it through a three-cornered orifice. I thought it would dry a little quicker in the tri-

* Civil Engineer, Boston, Mass.

angular form than in a square; and that I had arranged so that the two top sides had a possibility of expansion in case a bit of root got in, or something too big; that delivered on an endless belt, and the peat was carried off and dried in the usual way. A most excellent steam fuel was produced. It was excellent to have in the house before I produced the Aladdin Oven, because it is the quickest breakfast fuel the cook can possibly have, and is just as good for broiling over as charcoal.

VICE-PRESIDENT BROOKS. Does anybody else want to ask Mr. Atkinson a question?

MR. CHASE. I will say that there is a chance now for fools to rush in where angels fear to tread.

MR. ATKINSON. If there is any bigger fool than the man who invades the domestic kitchen, I should like to have somebody find him for me. I want to say right on that, that through the long period of experiment in developing the Aladdin Oven, beginning in the most complex way, as roundabout as all the scientificusses do, as well as the duffers, in order to get down to ultimate simplicity, I had for five years the most intelligent coöperation of an Irish cook; and I took that Irish cook with me when they invited me on to Columbia University to give a supper to two hundred people in a building where there was no kitchen. They paid the bills and I carried on four or five ovens and that Irish cook, put her down in the basement, ordered the materials and left her there by herself, and in the evening she served an admirable nutritious supper, ample in amount and variety, to two hundred people. I could give you a better lunch than you have had to-day and cook it on the table with a couple of common parlor lamps of the round wick variety, which burn one quart of oil in eight hours.

MR. E. A. W. HAMMATT. I was somewhat interested in the remarks made about the use of peat in East Lexington. If I recollect correctly, along in the early seventies peat was handled in Lexington and put on the market.

MR. ATKINSON. Yes, it was. Peat is so important and is such a universal fuel in Denmark that the amount which may be cut in one year is limited by statute to what will be restored in the natural order two hundred years hence. It is what we don't know about fuel that I have been speaking to you about.

VICE-PRESIDENT BROOKS. I would say in connection with this subject that Nat Wyeth, who was the pioneer in cutting ice on Fresh Pond, and was also connected with the Bay State Brick Company during its early period, made at the Bay State brick yards a lot of brick to be used in the construction of the brick ice-houses which stood on the shores of Fresh Pond; and in order to make them light he mixed with the clay a large proportion of peat, and when they were burned they weighed only a fraction of what an ordinary brick would weigh. When those buildings were torn down, some fifteen years ago, the bricks which were used in the cell work, lining up the inside of the houses, were taken away and used for partition walls in some buildings down in Cambridge. They created a good deal of wonderment at the time, people not knowing how they were made and not being able to account for their extreme lightness. I believe Mr. Wyeth also attempted to burn bricks with peat, but I think it was not successful. I think that we may say of him that he coined an expression that is capable of wide application, and perhaps if more people would remember it they would not be discouraged so often at seeming failure when they attempt to do something new. Mr. Wyeth was engaged in perfecting machinery for cutting ice, and he did not hesitate to go to almost any expense upon a machine, and if a failure occurred he always used to say: "It is worth just as much to know what will not work as to know what will."

MR. ATKINSON. That is a most interesting point. Of course the philosophy of that was that the peat in the interstices of the clay was burnt out in the process of burning the brick and left globules of air, the best non-heat and non-cold conductor in the world, and you therefore had the most effective non-heat conductor that could be made of clay. I wonder that that had n't been followed up for many of my own purposes. There is a field open for it now. One of the subjects which we have had to explore to the fullest extent, a covering for steam pipes and boilers, is waiting for a porous clay. Norton has made it somewhat in imitation of tufa, but we have n't yet developed it, — the lightest and most indestructible material with which steam pipes and boilers can be covered, or it may be made in slabs. This is an extremely interesting point. I have learned something to-day and I have got something which will be developed. [Applause and laughter.]

MR. CHASE. I remember seeing a number of years ago, it must be nearly twenty, a slab of something like fire-brick which is used in bakers' ovens, which had been made by a mixture of clay with sawdust and then burned, and my impression is that that was used in the construction of a mechanical filter at Marshalltown, Iowa. I think that is where I heard of it, but I forget whether it was made there or came from New York state. I think it is now in the office in North Carolina. My impression is it was a slab about 14 by 18 and 2 and ½ inches thick, of light brown color, and it weighed not over one third of what an ordinary bakers' oven slab of the same size weighs. It was sent to us with the idea that it could be used to strain the color out of water, but it was so porous that we found it would hardly take the bugs out.

PRIVATE FIRE SERVICES.

At the last annual convention of the New England Water Works Association, the following motion, made by Mr. Frank C. Kimball, Superintendent of Water Works at Knoxville, Tenn., was unanimously passed:

"That a committee of three be appointed by the President, whose duty it shall be to ask for the appointment of and to confer with similar committees from the American Water Works and other kindred associations, and also with the various underwriters' associations, to agree, if possible, upon some adequate means of controlling private fire supplies acceptable to all parties concerned, including therein all questions relating to charges therefor and similar matters."

Messrs. F. H. Crandall, of Burlington, Vt., R. J. Thomas, of Lowell, Mass., and Elbert Wheeler, of Boston, Mass., — the committee appointed in compliance with the instructions contained in the above motion, — would respectfully invite correspondence and suggestions from all interested in a fair and equitable assessment of the benefit conferred in supplying fire protection by means of private fire protective systems.

The committee, so far as their investigation has progressed, find that nearly everywhere, both in case of public and private ownership, it is customary to recognize the service of the water works to the public, in the line of fire protection, a frontage tax, hydrant rental, general appropriation, or an overdraft, serving as means to secure the assessment upon the property benefited, of the cost of fire protection.

The capacity of works necessary to supply the volume of water required to make private fire services of value, the leaks habitually permitted on unmetered services, to which fire services are no exception, and the stealing which not infrequently takes place from such services, all entail expense, to cover which an assessment should be made upon the parties directly benefited.

As in the case of schedule rate assessment, the convenience or advantage accruing from additional fixtures, together with the

additional cost of the service, constitutes a basis for increased assessment, so in the case of fire protection, increased benefit and increased cost of service constitute a basis for increased assessment.

The individual benefit enjoyed by the possessors of private fire protective systems is far in excess of that enjoyed by the general public, to which latter benefit, by reason of payment of taxes, all are, to a reasonable extent, entitled.

As Hon. J. O. Hall, of Quincy, said at the 1902 Convention of the New England Water Works Association: "The individual taxpayer should not be compelled to bear any burden which, by any interpretation, can pass into an individual benefit to somebody else."

That private fire protection should yield the company, or department, furnishing it, a fair return; that a request for a service for fire or any other purpose, unaccompanied by willingness to furnish correct and trustworthy information as to the amount of water used or wasted through it, is unreasonable, and that the size of services, for whatever purpose used, should be kept well within the capacity of the system to supply, without excessive loss of pressure, are conclusions easily and speedily reached. How to determine an amount constituting a fair return is a question upon which the committee find room for a greater difference of opinion.

The committee promise, to all communications and suggestions, their thoughtful consideration.

F. H. CRANDALL,
R. J. THOMAS,
ELBERT WHEELER,
Fire Pipe Committee, N. E. W. W. A.

PIPES AND PIPE LAYING FOR THE METROPOLITAN WATER WORKS.

BY CALEB MILLS SAVILLE, DIVISION ENGINEER.

[*Read February 11, 1903.*]

Mr. President and Gentlemen, — Under authority of Chapter 488 of the Acts of the year 1895, the Metropolitan Water Board in the latter part of that year began planning for the construction of a pipe system to distribute water to Boston and its suburban cities and towns. After the organization of the Water Board, Mr. Frederic P. Stearns was appointed chief engineer. All of the work in the Metropolitan District, including the pumping stations, the pipe systems, and the distributing reservoirs, was placed in charge of Mr. Dexter Brackett, engineer of the Distribution Department. It is concerning the pipe system and the methods of construction employed thereon that I have pleasure in inviting your attention to-day.

THE DISTRIBUTION SYSTEM.

Except in the city of Boston the consumption of water is mostly for domestic purposes, although in several of the other cities and towns there are extensive industries using large amounts of water. In the report of the State Board of Health to the legislature of 1895 it was estimated that one hundred gallons per capita would be a reasonable amount for which to provide.

The probable growth of the district was carefully estimated and this taken with the per capita consumption was used as a basis for proportioning the pipe lines.

In Boston, and in many of the cities and towns in the northern part of the district, the conditions were such as to make it advisable to maintain both high and low service systems, in order that on the one hand adequate pressure might be had on the elevated portions, while on the other hand excessive pressure and conse-

quent expense for pumping might be avoided in the low parts. A most comprehensive scheme for supplying the district with water had been laid out in the State Board of Health Report for 1895. The plans there suggested, while generally followed, were elaborated and developed as detailed investigations and surveys were made for the actual work. With Chestnut Hill Reservoir and the pumping stations as a center, two 48-inch pipe lines run in a general northerly direction to Spot Pond, supplying low-service water on the way to Arlington, Somerville, Medford, Malden, Everett, Chelsea, East Boston, and Charlestown. These lines follow different routes, one passing through the westerly parts of Cambridge, Somerville, and Medford; the other through the easterly parts of these cities and through Malden and Melrose. From Malden a branch from this latter line runs off to Everett, Chelsea, and East Boston. From the same center two more 48-inch lines run easterly for the low-service supply of Boston; 48-,36-, and 30-inch lines run southerly for the high-service supply of this city, and for the whole supply of Quincy and Milton. Westerly a 36-inch main carries the supply of Watertown and Belmont, with provision for the future supply of Newton. The high service supply of the towns and cities in the northerly part of the district, and the entire supply of Stoneham, Revere, Nahant, Swampscott, Melrose, and Winthrop, is pumped from Spot Pond into the High-Service Reservoir* in Middlesex Fells.

At the same time that surveys and investigations were being made for location, studies, plans, and contracts were made for the pipes, specials, valves, and other appurtenances for the pipe lines. The pipes † and special castings were made substantially according to the standard specifications for cast-iron pipes reported in the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, Vol. 16, p. 330. For the storage of these materials on their arrival and for convenience in sending them out, land was acquired temporarily or permanently for pipe-yard purposes as conveniently located as possible with reference to the proposed work and to the railroads. In the pipe yards the pipe is stored

*Paper on Fells Reservoir, by Mr. J. L. Howard, Division Engineer, Metropolitan Water Works, JOURNAL NEW ENGLAND WATER WORKS ASSOCIATION, vol. xv, p. 20.

†Paper by Mr. Dexter Brackett, Engineer Distribution Department Metropolitan Water Works, JOURNAL NEW ENGLAND WATER WORKS ASSOCIATION, vol. xiii, p. 325.

FIG. 1. — METROPOLITAN PIPE YARD, SOMERVILLE.

FIG. 2. — 48-INCH PIPE LINE FLOATED BY WATER USED IN PUDDLING.

on spruce runs in tiers to a height of about 12 feet. It is handled by a 55-foot boom derrick of 10 tons capacity, held in place by five 1½-inch wire guys fastened to "deadmen," and rests on a block of concrete 4 feet thick and 4 feet square. As it was necessary to have a certain number of men in the pipe yard, it seemed best to operate the derricks by hand power rather than steam. Plate I, Fig. 1, is a view of the Somerville pipe yard.

APPURTENANCES AND SPECIAL DETAILS.

On pipes 30 inches diameter and larger, manhole pipes for affording entrance to the inside of the pipe line were placed at convenient intervals. These pipes were special castings about 3 feet long with bell and spigot ends, having a flanged circular opening in the top, on which was bolted a cast-iron cover with a gasket between. All gate valves of 12 inch and larger were made from patterns specially designed for this work, owned by the Board and loaned to the maker. The iron castings are made from superior quality metal and thoroughly tested for their work. The composition castings are made of new material of the best quality, the valve seats and faces being 3 parts copper and 1 part zinc; all other composition is of 88 parts copper, 10 parts tin and 2 parts zinc, having a tensile strength of not less than 30 000 lbs. per square inch. Each valve has the maker's initials and the year cast on the outside of the dome. The seats and faces are faced with composition inserted in a dovetailed groove, solidly hammered in and fastened with brass or composition screws. Before delivery the valves are tested at the contractor's expense as follows: First, heads are secured at each end of the casting, the valves opened and a pressure of 250 lbs. per square inch applied; second, the face joints of the valves are tested by closing the valves, leaving one end of the casting open and applying a pressure of 150 lbs. per square inch to the other; this operation is then reversed and the other face of the valve tested.

All of the gate valves except a few near the pumping stations are operated by hand power. This method insures slow closing and is a safeguard against ram. At the pumping stations, however, hydraulic power is used to operate the large valves in the mains which are most often used. No valves larger than 36 inches in diameter have been used, reducers, making a section like

a venturi meter with a 36-inch valve at the throat, being placed on the larger-sized pipes. This method greatly reduced the cost, and inappreciably affected the head.

A number of check valves have been used on the system, which, while generally following usual types, are, like the gate valves, made from specially designed patterns.

Two sizes of air valves are used, one having a gross opening in the shank of an inch diameter, the other of 1½ inches. These valves are not self-acting, but require to be both closed and opened by operating a screw in the stem, a shield around the upper portion of the valve protecting the operator from water when the air is driven from the pipe. The advantages of this style valve are that it is positive in its action and, on account of proximity to the pipe, unlikely to freeze.

In several places where the pressure afforded by the Metropolitan mains is higher than necessary for the supply of the town, reducing valves, either of the Ross pattern or a specially designed balanced valve, are used to reduce the pressure on the local connection.

Where a joint opening of less than one inch would be required, changes in direction were made with 12-foot lengths of straight pipe. Changes in direction requiring sharper curvature than this were made with specially cast pipes. Whenever these special castings were used, the joints were run solid with lead, and the pipes solidly backed with concrete.

Lugs were cast on all branches, and the cap or gate controlling the opening securely bolted to the main line. In laying the pipes under several reservoirs, provision was made against the tendency for the outside water pressure to float the pipes if empty by fastening them to concrete blocks by iron straps encircling the pipe. All summits where air might collect are furnished with air valves, and all low places, where possible, have blow-off branches for draining the line.

The specifications for the pipe-laying were drawn with the greatest care, and the consensus of opinion among contractors seems to be that the signing of a Metropolitan pipe-laying contract is equivalent to giving a quitclaim deed. However this may be, no lawsuits have been necessary in settling claims since the beginning of the work.

CONSTRUCTION WORK.

The lines of the trench in streets followed as closely as possible established street lines, and where practicable such a location was chosen that the pipe line would neither be under street car tracks in the center nor in the location of surface drains in the side of the roadway. Alignment was given by spikes driven on a convenient offset and at intervals of about fifty feet on tangents. Spikes were also driven on all points of curvature and at short intervals on curves. These spikes were leveled over and grades given on them which were afterwards tranferred to grade boards set up over the center of the trench. Few sewers can show better lines and grades than those in the pipe lines of the Distribution Department.

The pipes were hauled to the trench by the contractor, being delivered on his teams at the pipe yard by the Commonwealth. In the case of the larger sizes of pipes, it was soon found most convenient to use teams made specially for the work. After delivery the contractor was responsible for all materials until the pipe line was accepted and the final payment made. This provision was rigidly enforced, and resulted in much greater care being taken of the materials. As it was, almost every final estimate contained a deduction for broken pipes and small articles lost or stolen.

In excavating the trenches care was taken to interrupt traffic as little as possible, and the trenches were bridged at short intervals to accommodate foot travelers.

The road metal or other surfacing material was first stripped and carefully saved to be replaced.

As a general thing it was intended to lay the pipes so that the axis would be about five feet below the surface of the ground. This necessitated very many changes in water-service pipe and in some cases both sewer and gas connections also. Where large pipes were to be laid it seemed best to hold to the line and grade and change existing structures. In the central parts of the older towns and cities many structures were encountered, as water and gas pipes, sewers, drains, and catch basins. Those recently built were fairly well located, and the plans were made to avoid them as far as possible. The older structures were usually not only

without recorded location, but in many cases out of the memory of the oldest inhabitant, even as to utility.

In some cases most obstinate worship seemed to attach to some old structure like a fire cistern dating from the time of the old hand engines and of a size that the modern engine would exhaust in fifteen minutes. No amount of diplomacy was usually sufficient to obtain permission to fill these up, and offsets had to be made in the pipe line or expensive measures taken to ensure the permanency of the basin and protection of the main if by any great favor it was permitted to lay the pipe through the walls.

In several places the existing location of the sewer was such that the pipe line was carried deep down below everything. In the case of small-sized pipes this method was much less expensive than the relocation of the many service pipes in thickly-settled communities. When existing sewers and drains were found in locations where it was impossible to change the pipe line or the house connections, parallel sewers were laid to take the drainage. The irresponsible way in which the older lines of gas pipes meandered from side to side of a well-laid out street was a thorn in the side of the locating engineer, and suggested that the same surveyor had perhaps been employed who laid out the older streets of Boston.

In a number of instances the pipe lines passed through streets built over soft and marshy ground. If the depth of soft material was great a pile foundation was used; if it were only a few feet, concrete piers were substituted for the piles; and if only of very shallow depth the material was entirely excavated, and the grade of the pipe line lowered or the trench filled with suitable material up to the proposed grade, and the pipes laid on the new foundation. In places where much mud was encountered, every precaution was taken to backfill entirely around the pipe and for six or eight inches over its top with clean gravel before any of the mud was replaced.

Where the material was suitable, water was used for settling it back again into the trench. The use of water for this purpose caused considerable discussion with contractors. Some claimed that the proper method was to almost entirely fill the trench with earth and then flood with water, using a long bar to

make holes in the filling and allow the water to settle. Others preferred to fill the trench perhaps one third full of water and allow the material to settle through this into place. Still others combined the two methods by keeping a large hose stream continually on the backfilling material. All of these methods have their good points, and the best for any particular place depends upon the nature of the material. In using water to backfill great care should be taken with the larger sizes of pipes to prevent floating the empty pipe line. One or two instances of this happened where a 48-inch pipe line was raised and thrown out of alignment for a considerable distance from this cause. (See Plate I, Fig. 2.) This line was forced back into position and the joints recalked. In macadamized streets the trench was first filled to subgrade of the roadway, and then the best portions of the surfacing materials screened and deposited in layers, the largest size being replaced first, and the remaining materials in layers according to their size. The whole trench was then wet and rolled with a steam or heavy grooved roller.

With the larger sizes of pipe there was usually some surplus which if good gravel or sand was readily disposed of. The cities and towns where work was under way were given the first opportunity to secure it. In some of the trenches for pipe twenty inches and under there was no surplus, and the contractor was obliged to haul material from elsewhere to fill portions of the trench.

In cutting the pipes it was found best to mark entirely around first with a diamond point on the outside, and if the pipe was large enough to enter, on the inside also, before beginning with the dog chisels. In this manner very clean cuts were made and few pipes broken.

In jointing the pipes either canvas or steel jointers were used, the former being preferred. The joints, except in few cases, were all run from the top and filled by continuous pouring. If any joint failed to fill, it was usually dug out, melting not being allowed, except for some extraordinary reason.

When a pipe was lowered into the trench it was lined and graded by the inspector, and pairs of wedges driven home in two places underneath. After the joint was yarned, the inspector tried the depth of the lead space with a gage, and, if satisfactory,

the joint was poured. As soon as possible after the joints were made they were covered, to prevent the lead being drawn out by expansion and contraction of the iron, if exposed to the sun. The pipes usually were placed in the trench by a derrick, operated by hand and spanning the trench. In the case of the line on Commonwealth Avenue, Newton, however, where a 15-foot trench was excavated through the rock to accomodate a future line, the pipes were rolled sidewise down an incline and placed by a tackle hung to an overhead beam.

At two brook crossings, each about fifteen feet wide, where it was undesirable to go below the bed, and unwise to contract the water-way by passing a large pipe through it, the grade was carried so that the top of the pipe was about a foot from the street surface and protected against damage from steam-roller or street-car weight by a curved steel plate supported by I-beams on either side of the pipe. Stony Brook, West Roxbury, was crossed by a self-supporting 36-inch steel pipe 38 feet long.

Usually the pipes were laid uphill, breaking the line when the summit was reached and beginning again at the bottom. This was especially necessary in the larger and heavier pipes, to ensure getting the spigot home in the bell.

Where there were no bridges, railroad tracks were crossed under by an open trench, the tracks being temporarily supported by large timbers placed by the railroad at the expense of the contractor. Several streams and railroads were crossed, either by hanging the pipes to the iron stringers of the bridges and building around them boxes sufficiently tight to protect from frost, or by supporting the pipe on top of the bridge beams.

It is remarkable what slight protection will prevent freezing if sufficiently tight to shut out drafts. The 12-inch pipe supplying the high portions of Milton in making a crossing 115 feet long at West Street, Hyde Park, is protected only by a steel plate ¼-inch thick on the bottom, 8-inch I-beams on the sides, and 4-inch planking on top. With a flow of about six gallons per minute, the water in this pipe did not freeze during the coldest nights of this winter. In Medford the 20-inch and 48-inch pipes are carried over Mystic River in a plate girder bridge resting on stone abutments.

On only two pipe-laying contracts have attempts been

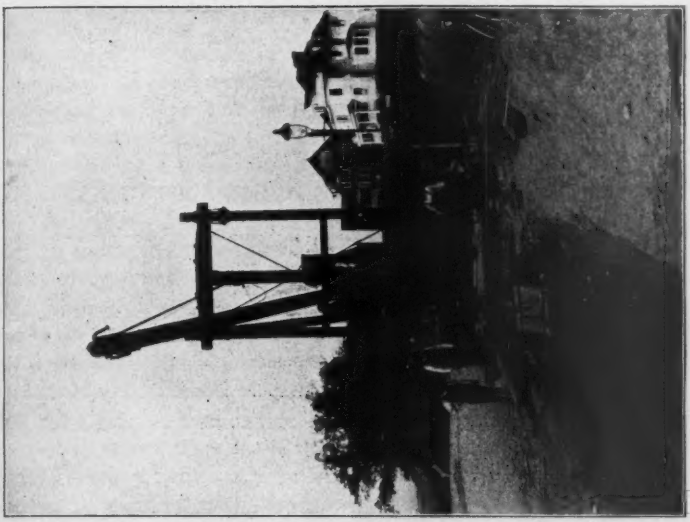


FIG. 1. — BYER TRENCH MACHINE, USED ON SECTIONS 19 AND 24.

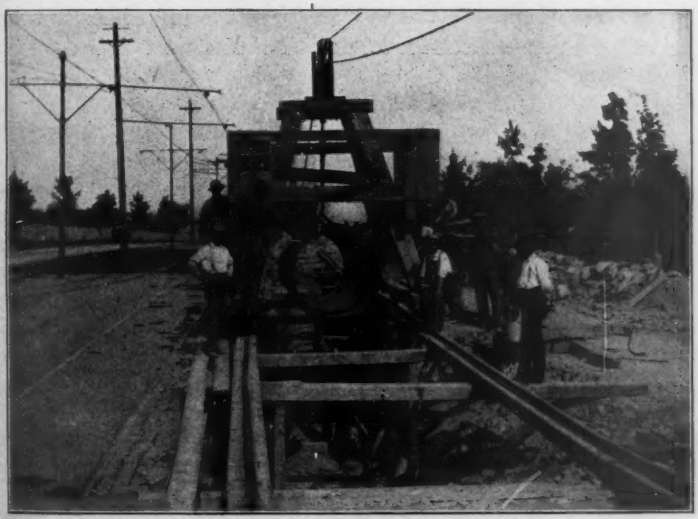


FIG. 2. — MOORE TRENCH MACHINE, USED ON SECT. 4 SUPPLY PIPE LINES.

made to use machinery either for excavating or pipe laying, although steam derricks have been used in a number of places where the nature of the work required a considerable excavation and much pipe laying in a contracted area. A steam excavating machine was used somewhat by E. W. Everson & Co. on Section 19, in a gravel trench, but with indifferent success; and later this same machine was used in excavating for the laying of a 20-inch pipe under Charles River between Newton and Watertown. This machine, which is shown in Plate II, Fig. 1, consisted of a double-drum hoisting engine, mounted on a platform which also carried a boom derrick on a turntable. This platform rested on flanged wheels running on T-rails. By means of "deadmen" and ropes attached to the engine drums, the machine could be drawn forward or backward on the rails. Attached to the boom of the derrick was a bucket similar to that used in a dipper dredge, and by means of wire ropes and an anchor this bucket could be pulled some distance from the engine, dropped into the trench, and when pulled back would be filled with material from the trench bottom. When the engine was reached the bucket could be hoisted by the derrick, turned to one side, and dumped alongside the trench.

On Section 4, Supply Pipe Lines, a machine designed by the contractor, Thomas F. Moore, was used which was very satisfactory in its working, and apparently effected considerable saving over hand methods both in trenching and pipe laying. (See Plate II, Fig. 2). Usually when a large pipe is laid through a narrow street it is necessary to close that street to travel, to the great annoyance of the public. Beside this, the contractor himself must arrange to have all his pipes hauled on to the ground before the street is closed. The excavated material is piled high in every available place, to the damage of lawns and fences, no matter what care is taken. With this machine there is no material stored alongside the trench, except the surfacing of the roadway. The material from the head of the trench is shoveled into buckets by laborers, hoisted by the cable, run backward, and dumped over the pipe laid at the other end of the trench The buckets have hinged bottoms, and the load can be dumped either from the cableway without stopping the machine, or the buckets can be lowered into the trench, the bottom of the bucket opened

and the load released simply by raising the bucket. This feature is of great importance when handling materials in which there are stones or other solid matter, which it would be unsafe to drop on the unprotected pipe.

In laying 48-inch pipes with this machine, only about 11 feet in width of roadway and from 150 to 200 feet in length is occupied. In a narrow street the pipes need not be stored alongside the trench, but can be laid as soon as brought to the ground, and no time lost to the pipe-laying gang as would usually be the case. The pipe is dropped alongside the trench where convenient, and rolled under the cableway on to timbers over the trench. It is then pulled up by the travelling carriage, taken to the proper point, and lowered into place. The usual tedious work of forcing the pipe into place with bars is avoided, the pipe being snubbed home and held there by the machine until received by wedges at the required grade. Two men in the car and the engineer take the place of the subforeman and derrick gang usually employed.

Considerable rock work has been necessary in trenching for the pipe lines, some of the heaviest work being done during the past year in excavating for a 60-inch line in Medford and for 48-inch lines in Newton. Plate III, Figs. 1 and 2 show a rock trench on Commonwealth Avenue, Newton, previous to laying pipe and after one line was laid. In the future it is expected to lay lines parallel to both of these, and at this time enough rock was excavated so that hereafter no rock work would be necessary in these places.

A number of long, and in some cases difficult, river crossings have been made on the work, and the methods employed varied considerably. Two crossings of the Charles River, Cambridge, and of the Mystic River, Medford, were made with double lines of 36-inch pipes, connected with a single 48-inch line at each end by a Y-branch. These pipes were laid in six-pipe sections, the spigot end of the section to be laid being specially cast with a taper to fit into a leaded joint in the bell of the section previously laid. The sections to be laid were fastened to a truss on the side of a pipe-laying scow, and could be raised or lowered as required.* When at the proper point the pipe section on the

* A more detailed description of the submerged pipe laying may be found in *Journal Assoc. Eng. Socs.*, Vol. XXVI, 1901, p. 196.

FIG. 1. — ROCK TRENCH READY FOR 48-INCH PIPE.

FIG. 2. — ROCK TRENCH WITH 48-INCH PIPE.

truss was forced home by hydraulic pressure, a diver guiding the spigot end into the receiving bell. After being laid, all joints were recalked by the diver. Changes in direction were made with ball and socket joints having a maximum deflection of 1: 10. The trench across the river was previously dredged for the pipe, and in the case of the Mystic crossing a pile foundation was used for the entire distance.

At the Malden River a double line of 36-inch pipe was laid in a coffer dam, one half of the work being done and the dam removed before work was begun on the other half. The Saugus River, Lynn, was crossed by pipes laid in a double wooden frost box, supported on a pile foundation as far as the channel, and this by means of an inverted siphon. This was 45 feet between the vertical legs, and the top of the horizontal portion was about 21 feet below mean high water. It was built of hard pine timber, 6 inches thick, thoroughly bolted and keyed together, making a box 4 feet 8 inches by 3 feet 8 inches over all, inside of which was placed a 20-inch pipe surrounded by Portland cement concrete. At Mystic River between Medford and Arlington, where the water was shallow, a sand-bag dam and close sheeting was used to lay a 20-inch pipe with ordinary joints. At Charles River, between Newton and Watertown, as mentioned above, a machine was used for excavating and handling the pipes. The material excavated was piled around a section about fifty feet long, which when the tide was low could be pumped clear of water and the pipe laid. On the return of the tide, backfilling would be done and further excavation. The rise and fall of the tide being only a few feet, work of this nature could proceed at any time.

For the supply of East Boston a 24-inch pipe with spherical joints was laid under Chelsea Creek. Previous to this the supply had been carried by two pipe lines, one 20 inches and the other 24 inches in diameter. The 24-inch line was laid in 1871, with pipe similar to those above described. The 20-inch line was laid in 1850. Below low water these pipes were laid in three-pipe sections, each pipe being 9 feet long and having flanged joints. At the end of each section was a curious swivel joint, allowing the freest possible motion vertically, but being rigid to horizontal movement. These joints made a series of right-

angled offsets in the pipe line, which must have resulted in a considerable loss of head. After removal, the pipes both above and below water were found to be very badly tuberculated, the inside diameters being reduced as much as two inches by a solid mass of incrustation. The pipes of this line above low water originally had their walls $\frac{7}{8}$ inch in thickness, but the whole barrel was somewhat reduced, and in places the iron was so soft that $\frac{1}{4}$ inch could be dug out with a pocket knife. Below low water the pipes were $1\frac{1}{4}$ inches thick, and had been covered with clay. Where this material was solidly bedded about the pipe the protection was perfect, even the rope slings used to lower the pipe being found attached when the pipe was raised. The new line was made up with 24-inch pipes, having ball and socket joints similar to those used with the 36-inch pipes at the Mystic River. The line below low water was wholly composed of these pipes,which were laid from a curved slide on the side of a pipe-laying scow. One end of the line was securely anchored on one side of the river and other pipes put into the slide, the joints leaded, and the pipes pulled down the slide to the river bottom by warping the scow ahead.

Under Mystic River at Chelsea North Bridge, two inverted siphons of the pattern used at Saugus River, but containing pipes of 30 inches and 24 inches respectively, had been laid, the first in 1850 and the second one in 1864. On account of the widening and deepening of the channel and reconstruction of the draw at this point, it was found necessary to replace these pipes. Both lines were badly tuberculated, being reduced in diameter from $2\frac{1}{2}$ to 4 inches. The 30-inch pipes were of Scotch make, $\frac{7}{8}$ inch thick, having bells with joint room $6\frac{1}{2}$ inches deep and $\frac{3}{8}$ inch wide, run solid with lead. Both of these pipes had been covered with concrete boxed with heavy timbers, and the 30 inch siphon copper sheathed on the uprights. All the bolts in the latter siphon were of copper, and were in excellent condition. The other box was put together with iron bolts, which were badly deteriorated except in the bottom. This portion had been covered with clay, and was in good condition. Both boxes where exposed between the river bottom and low water were almost wholly destroyed by limnoria.

Although Chelsea and East Boston were now supplied by a

FIG. 1. — LAYING 12-INCH PIPE ACROSS NEPONSET RIVER.

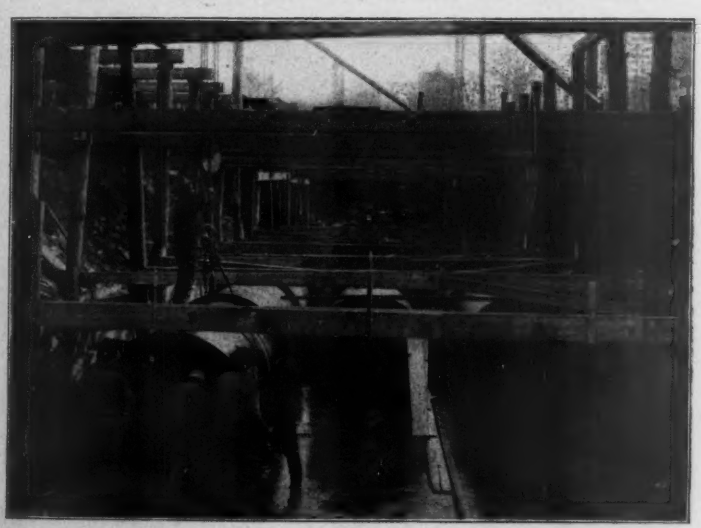


FIG. 2. — LAYING 3 60-INCH PIPE LINES IN COFFER DAM UNDER CHARLES RIVER, NEWTON.

42-inch pipe recently laid, it seemed best to still maintain a supply in this location. The greater depth and breadth made the use of a siphon impracticable, and a tunnel 6 feet in diameter and 145 feet in length was constructed, having a shaft on either side of the channel, in which a 24-inch pipe line was laid and connected with the pipe previously in service on either side. About 45 feet of each shaft is composed of steel cylinders 8 feet in diameter, made of ½-inch plates, three 9-foot lengths of cylinder being set up on the deck of a lighter and partially lined with brick masonry. This portion was then lowered into position and allowed to settle, necessary sections being added at low water to bring the top well above the highest tide. On top of this cylinder an air lock was bolted, and the work proceeded by means of the ordinary methods used in pneumatic work. In both shaft and drift circular wooden lagging was used, forming a solid wooden ring 5 inches thick outside the brickwork.

At the Neponset River in Hyde Park a 12-inch line made up of pipes with ball and socket joints was used. These pipes were floated into position over a dredged trench by means of oil barrels securely lashed to the pipes, (see Plate IV, Fig. 1) and when all was ready these were cut away and the pipe allowed to settle into place. A subsequent test of this line indicated that it was almost bottle tight.

The Charles River between Newton and Weston is being crossed by three parallel lines of 60-inch pipes covered with concrete. This work is being done by means of a coffer dam. (Plate IV, Fig. 2). The river and flats, which are at times under water, made it necessary to work in the coffer dam for about three hundred feet. The maximum depth of the water is about seven feet, and the bottom of the pipes in the channel about seven feet below the river bed. The coffer dam is a two-story structure, the upper part above the river bed being fifty feet wide in the clear and having double walls of 4-inch tongued and grooved spruce sheeting. The double walls are five feet apart, and filled in with sand and mud from the excavation. Inside this dam a trench 25 feet wide, sheeted with 3-inch by 9-inch spruce timber, is dug in the river bottom to a depth of about seven feet at the center of the channel and fourteen feet deep near shore. In this trench the pipes are laid. The material encounted was sandy gravel, containing

considerable water, as much as six million gallons being pumped per day by the 6-inch and 8-inch centrifugal pumps.

An interesting feature of this work is the running of the joints solid with lead and the calking of the lead joints both on the inside and outside. For this work no gasket was used in the joint, but a band of steel 2½ inches wide, $\frac{3}{16}$ inch thick, and the length of the inside circumference of a 60-inch pipe was made up in circular shapes, fitted against the inside of the joint, and held securely in place by bolts and nuts, placed in such a manner that by screwing them up the steel band would be expanded against the pipe walls in the same manner a pair of calipers are opened. When the joint was run, men would calk the inside of the joint as well as the outside, thus making a smooth and tight joint. On previous 60-inch lines the joints had been pointed with Portland cement mortar on the inside.

After the pipe lines are completed, and before being accepted, they are tested by such hydrostatic pressure as seems desirable. The pressure is usually obtained by a hand-power force pump, taking water from a nearby hydrant and delivering it through a meter into the pipe line through a hole tapped for an air valve.

After the construction work is all done, record plans (Fig. 1) are made up showing the general location of both plan and profile to scales of forty feet and four feet to the inch, horizontally and vertically, respectively. Record detail plans (Fig. 2), are also made to a scale of twenty feet to an inch, showing all valves and appurtenances that it might be necessary to locate quickly.

COST OF PIPE-LAYING WORK.

Table No. 1, page 220, shows the total cost to the Commonwealth of laying several pipe lines of various sizes. On account of lower prices both for materials and labor previously prevailing, this work cost much less than would similar work to-day.

Table No. 2, page 222, shows the prices bid by contractors for laying pipes from the beginning of work to the present time. In making up the average shown in Column 6, a few have either a very high or a very low bid omitted. This was done because it seemed that the judgment of the great majority of bidders was a more reliable estimate of the amount that should be received for the work, and extreme prices either were errors or indications

of an unbalanced bid. For the 48-inch pipes, of the 119 bids received, only 14 were rejected as being either too high or too low for a well-considered offer.

The bids under Contracts 30, 64, and 207 are large on account of the long haul for materials and location difficult of access. Under Contract 39 for laying 30-inch pipe, if the two highest bids were omitted the average of the others is $1.20 per linear foot. Under Contract 60 the bids for the 42-inch pipe were high on account of long haul and location, which was in narrow city streets containing many underground obstructions.

Table No. 3, page 223, is presented as an individual opinion of what, under ordinary circumstances and average conditions, pipes of the several sizes listed might be laid for under contract work at the present time. It is generally based on the foregoing information and on data collected during the work of construction. If used it is expected to serve as a guide, and is not a statement of the cost of pipe laying under any and all conditions.

BASIS OF COST TABLE.

Pipes, etc. —	*Average per cent. of cost of straight pipe.*
Small pipes (for blow-offs and connections)	1.50
Special castings	4.50
Valves	5.00
Miscellaneous materials	1.00
Total percentage to be added to the cost per ton of straight pipe	12.00

The heading Miscellaneous includes frames and covers for chambers, and payments for labor and miscellaneous materials not included elsewhere.

When pipe is $26.80 per ton, the cost per ton of the pipe line, including small pipes, specials, valves, etc., would be $30.02 (26.80 × 1.12). Thirty dollars per ton is used in the cost table, as the average cost of straight pipe recently purchased was in the neighborhood of $27.

Teaming. — The cost of teaming pipe on 21 contracts previous to 1898 was $0.26 per ton per mile, and the average haul from the pipe yards was 2.4 miles. In the above table $0.30 per ton per mile is used, with an average haul of $2\frac{1}{2}$ miles.

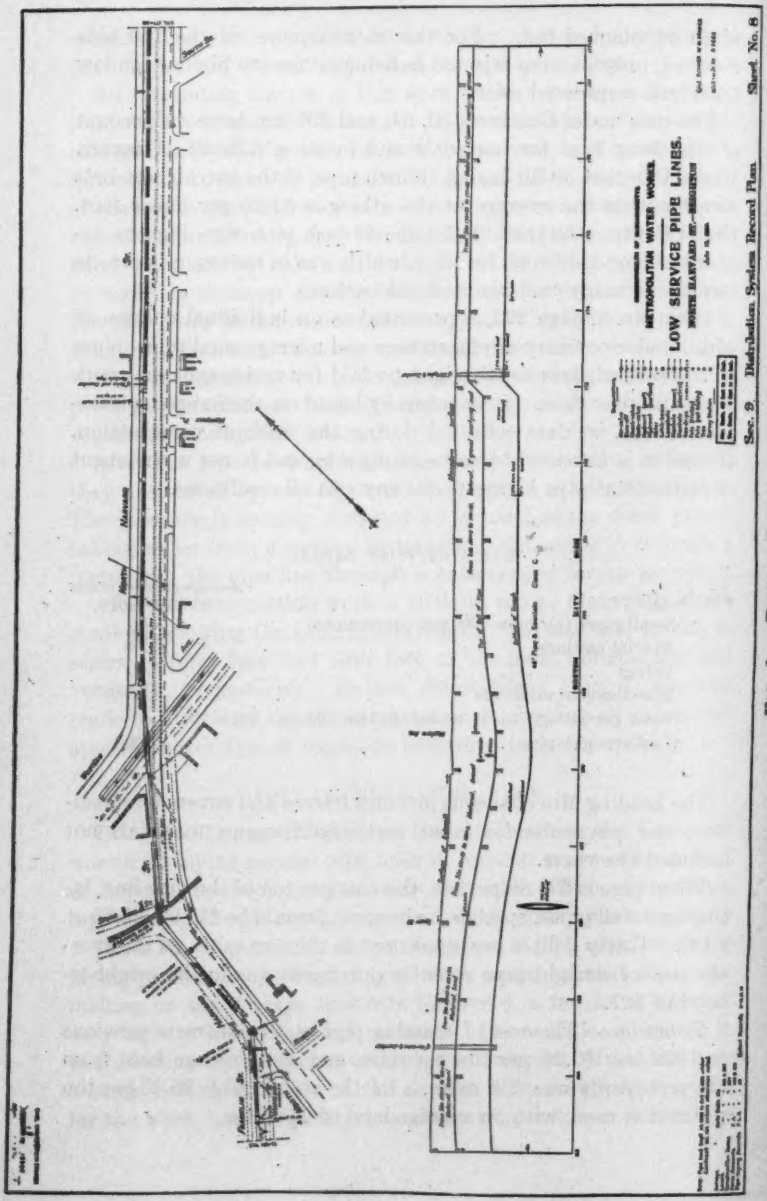


FIG. 1. — RECORD PLAN.

FIG. 1. — RECORD PLAN.

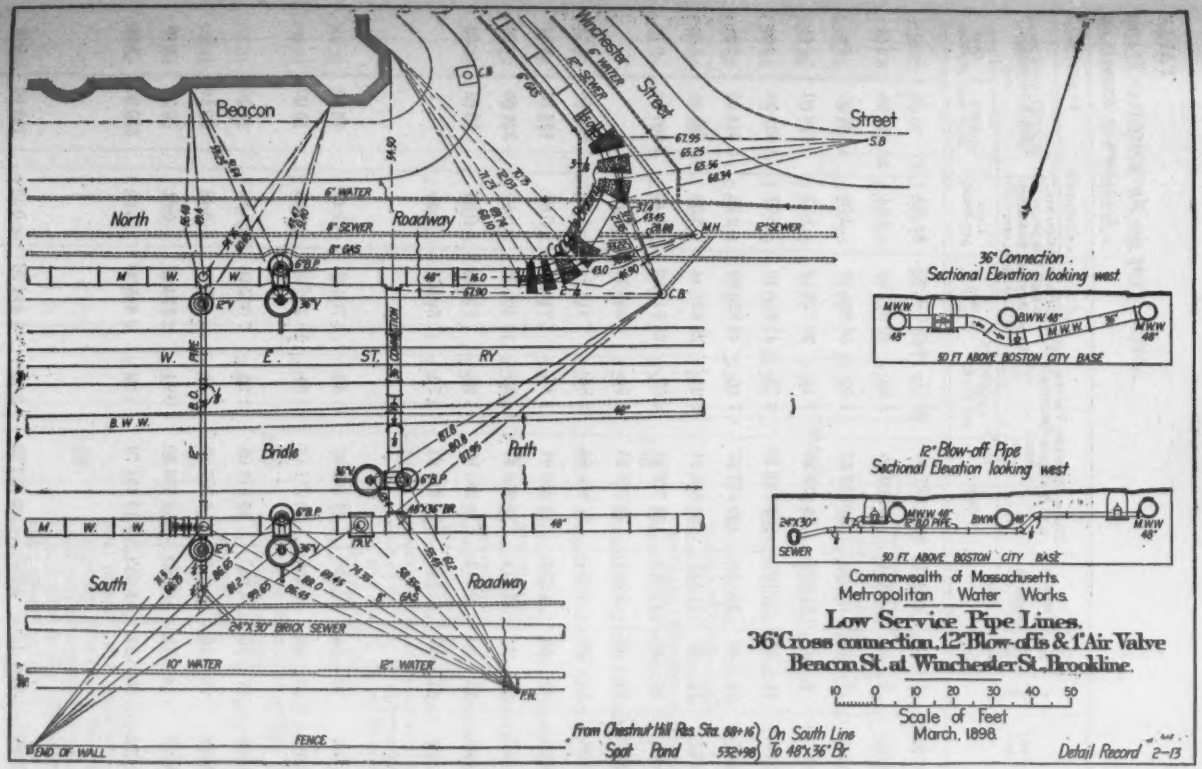


FIG. 2. — DETAIL RECORD PLAN.

TABLE

ACTUAL COST TO METROPOLITAN WATER

EXCLUSIVE OF EXPENSE FOR

Year Laid	Section.	Diam. Pipe. In.	Length of Section. Feet.	Pipes, Specials, Valves, and Manhole Covers, etc.		CONTRACT			
						Earth Excavation and Refilling, Pipe Laying, Building Chambers, etc.		Rock Excavation.	
				Cost.	Cost per Foot.	Cost.	Cost per Foot.	Cost.	Cost per Foot.
1896–7	4	48	18 804	$152 887 80	$8 07	$49 576 98	$2 64		
1896	2	48	20 354	140 309 03	6 89	39 517 92	1 94	$1 818 00	$0 09
1896	7	48	13 630	95 092 33	7 02	36 809 13	2 70	4 146 50	0 31
1897–8	9	48	11 968	85 276 33	7 15	20 722 15	1 73	496 00	0 04
1896–7	11	48	15 102	101 746 36	6 73	41 619 46	2 77	1 402 50	0 09
1897–8	19	48	18 118	129 917 57	7 16	42 830 92	2 36	5 344 50	0 29
1897	13	36	11 141	55 836 01	5 01	26 537 44	2 38	11 205 00	1 00
1898	20	36	17 413	79 729 45	4 57	25 644 82	1 47	3 007 92	0 18
1897	23	36	8 317	32 775 25	3 94	9 895 24	1 19		
1896	14	30	7 231	27 969 64	3 86	7 918 84	1 09	950 40	0 13
1896	15	24	4 252	10 260 91	2 41	3 712 71	0 87	127 75	0 03
1897	21	24	15 412	35 395 47	2 29	13 462 66	0 87	336 00	0 02
1896	15	20	9 742	19 285 80	1 98	7 774 96	0 80	36 02	0 003
1897	24	20	11 537	19 818 81	1 72	10 392 10	0 90		
1896	16	16	10 108	13 165 95	1 30	4 704 59	0 47	18 30	
1898	26	16	18 246	23 921 48	1 31	10 556 04	0 58	15 00	
1898	27	16	11 255	13 816 08	1 23	7 067 09	0 63	21 20	
1898	25	16	5 010	6 607 75	1 32	2 465 76	0 46	29 10	
1898	16	12	3 880	3 576 30	0 92	2 374 48	0 61	0 75	0 00
1902	30	12	8 625	10 624 73	1 23	5 625 38	0 65	320 90	0 03
1898	27	12	3 067	2 712 63	0 88	1 444 76	0 47	112 00	0 03

No. 1.

WORKS OF LAYING WATER PIPES.

ENGINEERING AND INSPECTION.

WORK.		ADDITIONAL ACC'T.		Total Cost per Foot as Laid.	Average Cost per Linear Foot.	REMARKS.
Extra Work, Change in Location, Pipes, etc.		Expense for Labor and Materials not otherwise included.				
Cost.	Cost per Foot.	Cost.	Cost per Foot.			
$158 35	$0 01	$11 042 11	$0 61	$11 32		City streets, either paved or macadamized.
		3 385 98	0 16	9 08		Macadamized roads and bridle path of boulevard.
2 243 31	0 16	4 960 95	0 36	10 08		Macadamized and gravel roads.
1 501 29	0 13	2 645 20	0 22	9 10	$10 10	Macadamized streets.
1 567 45	0 10	11 217 69	0 75	11 28		Macadamized streets.
2 637 49	0 15	6 000 03	0 33	9 85		Macadamized streets, gravel roads and bridle path.
1 600 39	0 14	1 952 16	0 17	7 56		Macadamized streets, gravel roads and unbroken woodland.
2 021 16	0 12	1 376 45	0 08	6 42	6 35	Macadamized streets.
		1 204 27	0 14	5 27		Macadamized city streets.
2 890 57	0 40	3 181 98	0 44	5 92	5 90	Macadamized city streets.
77 06	0 02	189 68	0 04	3 37		Macadamized city streets and gravel roads.
2 733 48	0 18	2 533 26	0 16	3 52	3 50	Macadamized city streets and gravel town roads.
274 79	0 03	442 60	0 05	2 86		Macadamized city streets and gravel town roads.
		3 315 65	0 29	2 91	2 90	Gravel town roads and macadamized streets, excluding cost of 840 lin. ft. approaches and 310 lin. ft. under Charles River, cost $7 721 24.
202 22	0 02	487 29	0 05	1 84		Gravel town roads.
1 022 64	0 06	3 503 85	0 19	2 14	2 10	Gravel town roads, and including three stream crossings on highway bridges.
2 475 61	0 22	3 776 90	0 38	2 46		Paved city streets, many local obstructions.
168 48	0 03	638 45	0 13	1 94		Gravel town roads.
71 89	0 02	208 84	0 05	1 60		Gravel town roads.
342 53	0 04	1 698 35	0 20	2 15	1 93	Gravel town roads, excluding cost of 146 lin. ft. laid under Neponset River, $2 003 51. Cost was increased by price of c. i. pipe being 40% higher than other contracts.
80 00	0 03	1 003 98	0 33	1 74		Paved or macadamized city streets.

TABLE No. 2.

PRICES BID FOR LAYING WATER PIPE—METROPOLITAN WATER WORKS.

Date.	1. Contract No.	2. Number of Bids.	3. Diam. Pipe. Inches.	4. Highest Bid.	5. Lowest Bid.	6. Average of Bids.	7. General Average.
1898	111	3	12	$0 73	$0 56	$0 67	
1898	134	4		0 75	0 45	0 60	
1902	239	4		1 15	0 53	0 71	$0 66
1896	41	11	16	0 89	0 45	0 65	
1897	58	10		0 95	0 47	0 68	
1898	133	10		0 85	0 53	0 68	
1898	134	4		0 80	0 65	0 72	0 68
1896	29	4	20	1 33	0 73	0 96	
1896	42	13		0 96	0 62	0 78	
1897	77	16		0 95	0 59	0 69	
1898	113	5		3 00	0 73	1 11	
1899	155	14		1 50	0 60	0 91	
1901	207	6		1 95	1 08	1 40	0 97
1899	155	14	24	1 80	0 60	0 97	
1901	207	6		1 95	1 25	1 47	
1896	29	4		1 47	0 83	1 09	
1897	79	12		1 15	0 68	0 87	1 10
1896	39	8	30	2 27	0 92	1 42	1 42
1896	30	4	36	1 90	1 38	1 67	
1897	64	19		2 65	0 98	1 55	
1897	70	14		1 85	1 06	1 36	
1898	109	11		1 89	0 98	1 18	1 44
1897	60	10	42	3 30	1 30	2 25	2 25
1897	60	10	48	3 34	1 60	2 27	
1896	30	4		2 35	1 92	2 08	
1896	31	6		2 60	1 79	2 28	
1896	33	5		2 73	2 24	2 57	
1897	58	10		3 85	1 81	2 28	
1897	59	13		3 45	1 63	2 19	
1897	66	15		3 24	1 25	2 08	
1897	71	13		2 37	1 70	1 97	
1897	75	6		2 68	1 55	2 05	
1897	92	9		3 10	1 49	1 97	
1898	114	3		2 75	1 85	2 18	
1898	124	5		2 25	1 80	1 93	
1902	231	7		4 05	2 21	2 43	
1902	235	6		3 25	2 21	2 54	
1902	237	7		3 35	2 19	2 61	2 23
1898	112	7	60	5 20	2 26	3 40	
1902	251	6		9 00	3 25	3 91	
1902	240	7		3 50	1 80	2 99	3 40

NOTE.—Prices given in this table are those bid for laying water pipe, and do not include rock excavation, building chambers, or extra work. Earth excavation, refilling, and pipe work are included.

TABLE No. 3. COST OF PIPE AND LAYING PER LINEAR FOOT.

Size of Pipe. Inches.		Weight per Length. Pounds.	Weight per Linear Foot. Tons (2 000 lbs.).	Cost @ $30.00 per Ton.	Teaming. 30c. per Ton mile. Haul 2½ miles.	Lead. 5c. per pound.	Miscellaneous Expenses.	Labor.	Cost of Laying.	Total Cost.
12	A	810	0 034	$1.02	$0.025	$0.100	$0.065	$0.45	$0.64	$1.66
	E	1 040	0 043	1.29	0.035	0.100	0.065	0.46	0.66	1.95
14	A	1 010	0 042	1.26	0.030	0.120	0.070	0.46	0.68	1.94
	E	1 310	0 055	1.65	0.040	0.120	0.070	0.47	0.70	2.35
16	A	1 215	0 051	1.53	0.040	0.130	0.070	0.50	0.74	2.27
	E	1 610	0 067	2.01	0.050	0.130	0.070	0.51	0.76	2.77
18	A	1 400	0 058	1.74	0.040	0.150	0.080	0.56	0.83	2.57
	E	1 910	0 080	2.40	0.060	0.150	0.080	0.58	0.87	3.27
20	A	1 610	0 067	2.01	0.050	0.180	0.090	0.61	0.93	2.94
	E	2 260	0 094	2.82	0.070	0.180	0.090	0.64	0.98	3.80
24	A	2 050	0 085	2.55	0.060	0.200	0.110	0.70	1.07	3.62
	E	3 000	0 125	3.75	0.090	0.200	0.110	0.73	1.13	4.88
30	A	2 860	0 119	3.27	0.090	0.250	0.130	0.78	1.25	4.52
	E	4 340	0 181	5.43	0.135	0.250	0.135	0.83	1.35	6.78
36	A	3 800	0 158	4.74	0.120	0.300	0.140	0.88	1.44	6.18
	E	5 900	0 246	7.08	0.185	0.300	0.145	0.93	1.56	8.64
42	A	4 920	0 205	6.15	0.155	0.350	0.175	1.02	1.70	7.85
	E	7 720	0 322	9.66	0.240	0.350	0.180	1.12	1.89	11.55
48	A	6 130	0 256	7.68	0.190	0.400	0.240	1.47	2.30	9.98
	E	9 740	0 407	12.21	0.305	0.400	0.245	1.57	2.52	15.73
54	A	7 510	0 312	9.36	0.235	0.450	0.275	1.66	2.62	11.96
	E	12 400	0 516	15.48	0.390	0.450	0.280	1.76	2.88	18.36
60	A	8 900	0 370	11.10	0.275	0.500	0.325	1.96	3.07	14.41
	E	15 100	0 628	18.84	0.470	0.500	0.330	2.12	3.42	23.27

Lead. — From the actual amount paid for lead on sixteen pipe-laying contracts having a total length of pipe laid of about twenty-two miles, varying in diameter from 12 inches to 60 inches, considerable variation in the amount of lead used per joint is shown. After careful examination, however, it seems that the extreme variations are due to well-explained causes, principally in carelessness, in putting more lead into the joint than is called for, and wasting in pouring the joints. At first sight it may seem absurd that a contractor would not be more than willing to fill a joint with yarn rather than lead. If, however, lead is cheap, the extra cost of the labor in yarning, added to the risk of being compelled to remove some if the joint is too full, may more than offset the cost of the extra lead. From experience on this work it appears that the rule given by Mr. Brackett of 2 × diameter of pipe in inches = lbs. of lead per joint, will cover reasonable use for straight line work and will include the extra joints necessitated by valves, specials, short lengths, and solid joints. In order, however, to provide for carelessness and to include also in the straight line the lead used in the joints of blow-off and other connections, it might be well to add two per cent. to this figure. In connection with the cost of lead it may not be generally known that the dross is worth saving, as it can be sold to the lead manufacturers. In making up the cost in the above table the cost of lead is found by $\frac{2 \times \text{diameter of pipe in inches}}{12} \times \$.05$, assuming that as lead can usually be delivered for less than five cents per pound, the difference in cost will cover any deficiency in amount.

MISCELLANEOUS EXPENSES.

Tools. — From careful inventory of the tools used on a large contract before and after the work, and by inquiries among several extensive contractors, it was estimated that the tools remaining after the work was done had depreciated about one half in value. This, added to the cost of those used up and lost, was found to be about four per cent. of the average cost per linear foot of the contract work.

Insurance and Incidental Expense. — Based on bond costing one half per cent. of amount insured, accident policy costing three per cent. of labor pay-roll, and incidental expenses, one per

cent. of labor pay roll, this item is estimated at 3.2 per cent. of the total cost per linear foot.

Lumber, Yarn, etc. — Based on the accounts kept on a number of contracts where particular attention was given to these items, a fair allowance was estimated to be about 2.8 per cent. of the total cost of the contract. The allowance, then, for the three preceding items is taken in the tables as 10 per cent. of the cost of pipe laying.

Labor. — The cost of this item is in a general way based on the contract prices given in Table No. 2. It is, however, increased somewhat to conform with the current price of labor, which is estimated to be about ten per cent. higher than it was four or five years ago.

In a general way, the cost of labor at the present time may be taken as follows:

Foreman, $100 per month.
Subforeman, $3 per day.
Calkers and yarners, $2.50 per day.
Laborers, 1st class, $1.75 per day; 2d class, $1.60 per day.
Double team and driver, $0.45 per hour.
Single team and driver, $0.30 per hour.

In addition to the cost per linear foot for laying the pipe, the following items should also be considered in making estimates:

Change in loc tion of existing work, and extra work. — In the progress of the pipe laying some work has to be done usually for which no contract price is made.

For this work the contractor receives the actual cost plus fifteen per cent. It is made up in the estimate for payment under one of two headings: first, "change in location," which is local in its character, being confined to those portions of the location where structures already exist; second, miscellaneous work of any kind previously mentioned. This work extends over the entire location. In giving the following costs, that per foot for the first class is based on the actual length of line in which obstructions were found, and is estimated to be an average of $0.09 per linear foot, with a variation from $0.01 to $0.30 per linear foot. These figures covered 38 miles out of a total of 62 miles of pipe laid, varying in size from 12 to 60 inches in diameter. The second item, "extra work," is taken from the cost on the above 62 miles, covering 36 pipe-laying contracts, and is estimated to

be an average of $0.03 per linear foot and to vary from $0.002 to $0.11.

The following costs are given as about the amount usually received on contract bids: —

Rock above grade, $3.50 per cubic yard.
Rock below grade, $5.00 per cubic yard.
Setting air valves, $3.50 each.
Chambers for valves 20 inches in diameter and larger, $50.00 each.
Chambers for valves 16 inches in diameter and smaller, including those for air valves, $40.00.

Acknowledgment. In the preparation of this article I am greatly indebted to the members of the Metropolitan Water Works force, and especially to Division Engineers W. E. Foss and J. L. Howard, for their kindness and courtesy.

DISCUSSION.

MR. H. G. HOLDEN. I should like to inquire if any provision was made for contraction on exposed places.

MR. SAVILLE. The pipe lines were not exposed to any extent. I think the only place where they are really exposed is the 36-inch pipe across Stony Brook. That was only about 34 or 35 feet long where exposed. The other pipes are covered in some way.

MR. GEORGE E. WINSLOW. I would like to ask with regard to these taper joints which were spoken of where they put down three pieces in a section. Was there any means provided for holding those against expansion? The reason I speak of it is, I should naturally think if there was any expansion the taper joint would give as quick or quicker than any other part of it and might work out of place.

MR. SAVILLE. In the Mystic River crossing, where the crossing was about one thousand feet long, there is a good deal of pipe to back up this taper joint. There was no provision to prevent the joints from pulling out.

MR. DEXTER BRACKETT. I will say that we have had, and I think we shall continue to have, leakage at these taper joints due to contraction of the pipes. With the change in the temperature of the water from 72 degrees in summer to 36 degrees in the

winter we find that leaks develop in the fall or early winter on the joints in the pipes crossing the rivers, and these leaks generally occur at the taper joints.

MR. HOLDEN. How are these leaks repaired?

MR. BRACKETT. By re-calking, and in some cases by bolting the joints together, the work being done by a diver.

MR. ROBERT L. COCHRAN. I came here this afternoon to see if I could get a little information, and I think I have come to the right place. I am connected with a small plant in Nahant, and I have been a member of the Association for a good many years, but I believe this is the first time I have ever had the pleasure of standing up here before you. We are supplied in Nahant now by the Metropolitan system. We have about 11 000 feet of 10-inch pipe across the beach, which has been in for twelve or fourteen years, and last summer we concluded to increase our pipe sizes, and we were attached on to the Metropolitan system, and they advised us to have a standpipe. Mr. Coffin was the engineer who had charge of its construction. It is 95 feet high and 30 feet across. This winter we have had considerable trouble. In the summer time the 10-inch pipe will not supply us with water, that is, during four of five months, but Mr. Doane tells me that at the present time he could supply all we use with an inch pipe. I understand from Mr. Coffin that our standpipe holds 400 000 gallons of water. Well, I used to scratch my head these cold nights and wonder how I was going to keep the pipe from freezing. I was advised to shut off the supply from the town, and let the town use it, but the town would n't use a foot of water out of that pipe all day, and then what was I going to do in case of fire? I would have to turn on the supply again. I used to go and look at the gage, and a week ago last Sunday, the first day of February, I found the water had run down to about 75 feet in the standpipe, where we are supposed to have 85 feet. I hunted around all day to try to find out where the leak was, but could n't find any. I ought to have mentioned that they have a regulator which reduces our pressure to so many pounds on the beach, and they don't allow us to touch that. So I said the thing to do is to send for the doctor; and on Monday morning Mr. Killam came down, and he said, "The regulator is n't working." I said, "Well, you are the man to fix it." So he fixed it, and told us

to report in the morning. Well, I went and saw it in the morning and it registered 94 feet, and of course the pipe ought to overflow, but it did n't overflow, and I found out that the ice had extended up seven feet above the top of the tank. I sent for the "doctor" again, and we shut off the town and let them use the water out of the standpipe, and the ice still stood there. Now, I have come here to ask the cause of that; and if any other member has a standpipe that acts that way, I would like to have him tell me what I can do to prevent it.

THE PRESIDENT. There ought to be somebody here who can tell him what ought to be done.

MR. DEXTER BRACKETT. I have had no experience with standpipes similar to that described by Mr. Cochran, but I should suppose that it was due to the freezing of the water around the sides of the standpipe, and that when the water rose it carried the ice up with it. I think the gentleman at your right (Mr. Merrill) has had some experience with ice forming on the inside of a standpipe.

THE PRESIDENT. Mr. Merrill, will you tell us something about it?

MR. FRANK E. MERRILL. Mr. President, we did have a standpipe in Somerville at one time, but it has been removed, and at the present time we have nothing of the sort. Mr. Brackett refers to some experience that I have had, and I was trying to think what it was. I do remember now that a little ice formed in that standpipe one winter, but there was only a slight motion to it, because we kept the pipe pretty well filled most of the time. But the ice did at one time move sufficiently to pull a bolt which held the ladder on the inside of the standpipe in position out of its hole. It did n't require very much movement of the ice to do that, but the people in Somerville and some of the newspapers in Boston got hold of the story, and one would have thought from the description given of it that the standpipe was about ready to collapse. It was a very simple matter to fix it. All it was necessary to do was to draw the water down below the bolt hole, which was, as I remember, about two thirds of the distance from the bottom to the top of the pipe; and I merely put a plug into the bolt hole, knowing that the standpipe was to come down, or presuming it was to come down in a short time, and not thinking it worth

while to put the ladder back into position securely. The ladder was rarely used, anyway, it being the inside ladder. I think this is all the experience with ice in a standpipe that I have ever had. Since the introduction of the Metropolitan high service system into Somerville, pressure is supplied to us from Spot Pond Reservoir and the standpipe has been removed.

Mr. Brackett. The point I wished to make with regard to the Somerville standpipe, and not particularly with regard to that more than any other, was that I think it is a fact that it was found that a very large amount of ice formed on the inside of the standpipe, even from the top to the bottom. I think this occurs in a great many standpipes. In cases where towns are supplied with ground water, that has a temperature of perhaps 45 or 50 degrees when it is pumped into the standpipe, less trouble from freezing occurs than in cases where the water is taken from a pond or stream with a temperature of from 36 to 38 degrees. I have serious doubts as to the advisability of pumping water into a standpipe at a temperature of 36 degrees unless the standpipe is housed in, and I should very much prefer that it should be housed in in any case. We have one standpipe which has been recently constructed with a tower around it, and observations taken there this winter show that no ice forms to do any injury. During the coldest weather a thin coating of ice has formed on the top surface, which soon breaks up, forming a slushy mixture but no solid ice.

To return again to the subject of pipe laying, we have with us to-day a gentleman who, I think, has had some recent experience with pipe laying under water in connection with the East Jersey Works, Mr. Cook, and perhaps he will be able to tell us something of interest.

Mr. J. H. Cook. I really have n't very much to say about pipe laying under water. We have six 16-inch pipes under the Passaic River, which have been in about ten years or a little longer. They are very heavy wrought-iron pipes, and are connected by ordinary screw joints. They were hauled into a trench, and, as I say, they have been in about ten years, and they do not leak. We have tested them recently by means of a small meter placed on a by-pass, and have found them to be tight. What Mr. Brackett refers to is probably the 72-inch pipe which has been

put in by the Jersey City Water Supply Company to supply Jersey City. This pipe has recently been put across the Hackensack River, and they got it across very nicely. It was a pipe which was covered with concrete rings, and was placed in a trench, and everything seemed lovely, but a slight leak did develop. The leak has been repaired. but I really can't say very much about the details of the work or much about the repairing of the leak itself.

PROCEEDINGS.

March Meeting.

Hotel Brunswick,
Boston, March 11, 1903.

Charles K. Walker, President, in the chair.

The following members and guests were present: —

Members.

S. A. Agnew, F. E. Appleton, Charles H. Baldwin, L. M. Bancroft, J. E. Beals, J. W. Blackmer, George Bowers, E. C. Brooks, E. W. Bush, J. W. Churchill, J. T. Cavanagh, George F. Chace, John C. Chase, F. C. Coffin, R. C. P. Coggeshall, M. F. Collins, H. A. Cook, J. W. Crawford, A. O. Doane J. N. Ferguson, F. F. Forbes, A. D. Fuller, F. L. Fuller, D. H. Gilderson, F. W. Gow, R. A. Hale, J. O. Hall, E. A. W. Hammatt, J. C. Hammond, Jr., E. W. Kent, Willard Kent, C. F. Knowlton, James W. Locke, H. V. Macksey, F. A. McInnes, F. E. Merrill, F. L. Northrop, Dwight Porter, W. W. Robertson A. T. Safford, C. W. Sherman, J. E. Smith, J. Waldo Smith, G. H. Snell, G. A. Stacy, W. F. Sullivan, C. N. Taylor, L. A. Taylor, R. J. Thomas, H. L. Thomas, D. N. Tower, W. H. Vaughn, C. K. Walker, F. B. Wilkins, G. E. Winslow. — 55.

Associates.

Harold L. Bond & Co., by Harold L. Bond; Wm. V. Briggs; Builders Iron Foundry, by F. N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; M. J. Drummond, by Walter J. Drummond; Hersey Mfg. Co., by Albert S. Glover and Walter C. Hersey; Henry F. Jenks; Lamb & Ritchie, by Harry F. Peck; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Mueller Mfg. Co., by W. L. Dickel; National Meter Co., by C. H. Baldwin and J. G. Lufkin; Pittsburg Meter Co., by George F. Bard; Rensselaer Mfg. Co., by Fred S. Bates; A. P. Smith Mfg. Co., by D. F. O'Brien and M. G. Millikin; Sweet & Doyle, by H. L. DeWolfe. — 19.

Guests.

F. L. Weaver, M. J. Dowd, R. J. Crowley, Water Commissioners, and Mayor C. H. Howe, Lowell, Mass.; Lyman J. Webber, Brockton, Mass.; Theodore P. Moorehead, Foochow, China; John W. Lovett, Beverly, Mass.; Edward Atkinson, President Boston Manufacturers Mutual Fire Insurance Co.; C. L. Wilkins and K. S. Sweet, Massachusetts Institute Technology, Boston, Mass. — 10.

(Names counted twice. — 2.)

The first business was the election of new members. The Secretary presented the following names of applicants, all of whom had been duly approved by the Executive Committee: —

For Resident Members.

Kilburn S. Sweet, Boston, Instructor in Civil Engineering, Massachusetts Institute of Technology ; Guy W. Ricker, Salem, Mass., engaged in general civil engineering practice ; George A. King, Taunton, Mass., Superintendent Taunton Water Works; Lyman J. Webber, Brockton, Mass., Engineer Water Works Pumping Station and Sewage Pumping Station.

For Non-Resident Member.

Charles L. Parmelee, New York, Consulting Engineer, N. Y. C. J. F. Co., and President General Construction Company.

By direction of the Association the Secretary cast one ballot in favor of the applicants, and they were declared elected.

President Walker then introduced Mayor Howe of Lowell, who spoke as follows: —

Mayor Howe. *Mr. President and Gentlemen,*— I suppose the high water in the Merrimac and the President of our water board are responsible for my being here to-day, and although I am very glad to be here, yet I think it is hardly fair to call upon me for any remarks, for I am not a speaker. If the water takers in the communities which are represented here could see the volume of water which is going through Lowell at the present time I think they would kick harder against their water rates than they do now.

I believe we in Lowell have the best water in the world. You might draw it from the faucet and bottle it up and sell it for any kind of fancy spring water that is being retailed in Boston to-day. It sparkles like champagne, and I drink it in preference to — well, to the spring water that my people buy. (Thomas did n't tell me to say this.) [Laughter.] The temperature of the water in the summer is about what it is to-day, and the water is always pure, wholesome, and has a good, clean taste. Now, gentlemen, I know that there are those here who are going to talk to you

about things that you are interested in, so I will not take any more of your time. [Applause.]

PRESIDENT WALKER. I am glad to see so many of you here to-day, gentlemen, and I congratulate you that spring has come and there will be no more frozen hydrants. [Laughter.] I read in the Boston *Advertiser* the other day that there was a great fire in Manchester and *twenty frozen hydrants*. Really, there were three hydrants frozen on top a little, but when the story got down here, the number had grown to twenty. I knew my friends would say to themselves, "What is the matter with Walker, twenty hydrants frozen around in one place?" but I thought they would n't believe it. [Laughter.] It is n't so, gentlemen; but we did have three hydrants that stuck on top. You ought to hear the papers and underwriters, like the gentleman here (Mr. Atkinson), go for me. But I slept all right, for I don't mind what people say about me because I have got accustomed to hearing them say 'most everything. Still I am glad that it is March, and there will be no more frozen hydrants. [Laughter.]

The President then called on Mr. George Bowers, City Engineer, Lowell, Mass., to read his paper entitled, "Underground Water; Suggestions on How to Obtain and Care for It." The subject was discussed by Mr. Edward Atkinson, A. O. Doane, and Charles N. Taylor.

The President announced that the Executive Committee had voted that the September convention be held in Montreal, and the June meeting in Waltham, and that Mr. Winslow, of Waltham, had been added to the committee, which consisted of Ex-Presidents Merrill and Holden, to arrange for the June meeting.

Mr. John C. Chase, Chief Engineer Water Works Company, Derry, N. H., then read a paper entitled, "A Little Talk about Water Rates."

Mr. Edward Atkinson, President Boston Manufacturers Mutual Fire Insurance Company, Boston, Mass., followed with a paper entitled, "Fuel; What we Don't Know about It." Messrs. Charles N. Taylor, Freeman C. Coffin, E. A. W. Hammatt, Vice-President Edwin C. Brooks, and Mr. Atkinson participated in the discussion which followed the reading of the paper.

Adjourned.

EXECUTIVE COMMITTEE.

RECORDS OF MEETING OF EXECUTIVE COMMITTEE OF NEW ENGLAND WATER WORKS ASSOCIATION, MARCH 11, 1903.

Present: President Charles K. Walker, Horace G. Holden, Edwin C. Brooks, J. C. Hammond, Jr., Charles W. Sherman, R. J. Thomas, L. M. Bancroft, Edmund W. Kent, George A. Stacy, Willard Kent, Frank E. Merrill.

Five applications are received from the following named parties: Charles L. Parmelee, of Orange, N. J.; Kilburn S. Sweet, of Boston, Mass.; Guy W. Ricker, of Salem, Mass.; George A. King, of Taunton, Mass.; Lyman J. Webber of Brockton, Mass.; who are all unanimously recommended for membership of the Association.

Consideration is given to place of holding next annual convention, and letters are read from Kenneth Allen, of Atlantic City, and J. O. A. LaForest, Chief Engineer, of Montreal. On motion of Mr. Thomas it is voted that the annual convention be held at Montreal, and that the present committee, consisting of Messrs. Holden and Merrill, be continued with full power to act.

The place of the June meeting is then considered, a letter from Mr. George E. Winslow is read setting forth the advantages of Norumbega Park and its surroundings, and it is voted that the June meeting be held at that place (Norumbega Park), with excursions to points of interest accessible therefrom, and a committee consisting of Messrs. Horace G. Holden, Frank E. Merrill, and George E. Winslow are appointed to make the necessary arrangements therefor.

Attest,

WILLARD KENT, *Secretary.*